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The New Irrigation Era

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THE NEW IRRIGATION ERA

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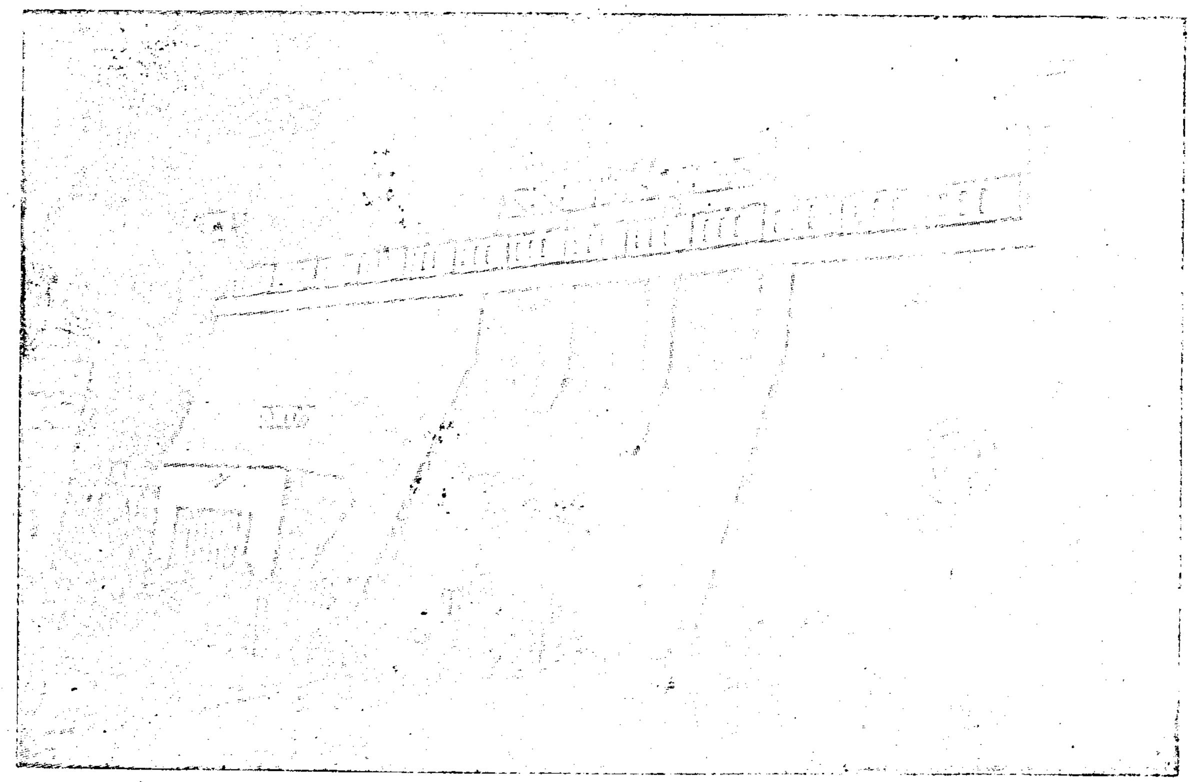

Front view of PWD Pavillion at
ALL INDIA TOURIST TRADE FAIR AT MADRAS – 1977

Thiru A. Mohanakrishnan Sr. Dy Chief Engineer (Irrigation) P.W.D receiving the Prize at ALL INDIA TOURIST TRADE FAIR—1977,

Prize Awarded at
ALL INDIA TOURIST TRADE FAIR—1977 FOR P.W.D

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THE NEW IRRIGATION ERA

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EDITORIAL.

In the first article of this issue Thiru K. Subbaraman, Senior Deputy Chief Engineer, P. W. D. (Investigation) gives an idea of the potential of the various river basins of Tamil Nadu and percentage of utilisation. As many of the basins are almost utilised the necessity to find fresh sources of water for the thirsty lands in Tamil Nadu by diverting the west flowing rivers to the Eastern slopes has been stressed. The various ways and means to find out how the existing potential could be used to the best advantage of Tamil Nadu have been enunciated. The basic approach is to use water economically and conserve the available quantity. All the above aspects have been clearly described by the author of this article.

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Thiru C. G. Jayaraman, Special Officer, Cauvery Valley Development in his second article mentioned that greater attention should be given to modernise the old irrigation systems to ensure equitable distribution of available waters, economic use of water for irrigation and extend the benefits of the saving in water to new extents wherever possible as almost all the available water resources in Tamil Nadu have been harnessed for irrigation and there is little scope for new river valley projects of large magnitude. In this connection the author deals with the brief details of modernising Vaigai Channels.

In the Third Article, the author Thiru H. S. Venkataramu, Executive Engineer, P.W.D. has explained the difficuties encountered in field in rock cutting and the author has discussed about deep cuttings in project with reference to Tungabhadra and Manimuthar Projects, the methods to be adopted for counteracting these useful and practical suggestions have been put forward by the author.

Thiru V. Ravindran of Institute of Hydraulics and Hydrology, Poondi gives brief account in his article " Electronics in Civil Engineering ", of the different methods adopted and principles involved in the functioning of several electronic instruments, supported by a few examples.

In the symposium held recently in New Delhi by " Central Board of Irrigation and Power " on silting of Reservoirs with special reference to estimating the life of reservoir and measures to arrest the rate of sedimentation the author have discussed a specific case of silt study of Perumal Tank in detail

A synopsis on Zoning of masonry in Sholayar Dam in Tamil Nadu and economic design aspects of Earth Dams of medium River Valley Projects in Tamil Nadu which are also presented at the Central Board of Irrigation and Power Meeting has been reproduced here for information to readers.

Last but not least, an abridged note furnished by Executive Engineer, Soil Mechanics Laboratory regarding P.W.D. Pavilion at ALL-INDIA TOURIST TRADE FAIR at Madras 1977 has been published for information to all the readers. In this context we like to inform all our readers with pride and joy that P.W.D. Pavilion was adjudged as the Second Best among the State Government Pavilions and a prize was awarded.

EDITOR.

RANDOM THOUGHTS ON MINOR IRRIGATION

by

K. SUBBARAMAN, B.E.,

Senior Deputy Chief Engineer (Investigation).

It has been estimated that the gross area sown and irrigated annually in Tamil Nadu are 190 lakhs and 92 lakhs acres respectively, the corresponding figures for nett area being 155 and 70 lakh acres respectively. The statement below gives the distribution of the nett areas so irrigated by different sources.

Canals	*Tanks*	*Open Wells*	*Tube Wells*	*Other Sources*	*Total*
23·10	23·20	22·63	0·65	0·80	70·38

The total quantity of rice produced in the State was estimated to be 58.7 lakh tonnes in 1975-76, requiring about 1,200 TMC of water, out of which the surface flows tapped and utilised from the various rivers were of the order of 700 TMC, leaving non-system tanks and wells to account for nearly 500 TMC.

An idea of the potential of the various river basins and the percentage of utilisation given below would indicate the somewhat sad plight of the State, so far as the scope for further utilisation is concerned. With a few exceptions, many of the basins are utilised almost to the limiting capacity.

River basin.	*Total yield in TMC*	*Utilisation upto IV plan i.e. 3/74 in TMC*	*Percentage utilisation.*
1 Araniar ..	5·7	4·6	81
2 Kortaliyar ..	14·7	*7·1	..
3 Cooum ..	1·2	*0·7	..
4 Palar ..	17·0	16·8	99
5 Ponniar ..	26·6	23·4	88
6 Vellar ..	37·0	29·3	79
7 Cauvery ..	511·8	499·5	98
8 Vaigai+	36·3	56·6	90
Periyar	26·8	..	..
9 Tambaraparani	51·3	41·1	80
10 Kodayar ..	21·8	21·8	100
11 Other Minor rivers ..	30·0	28·3	94
	780·2	729·2	93·5

*To be verified

It has therefore become an imperative necessity to find fresh sources of water for the thirsty lands in Tamil Nadu. The Government are seized of the problem of diversion of West-flowing rivers to the Eastern slopes, which would benefit the country to an extent of more than 1,000 TMC. The various aspects involved in such a process, however, are likely to be time consuming and benefits are not likely to be realised immediately.

In the absence of fresh and insufficient water resources, we have naturally to turn inwards, to find out how the existing potential could be used to the best advantage. A beginning has already been made in this direction in the shape of modernisation of the irrigation in the Cauvery Delta. But, by and large, our irrigation methods, not only in this State, but also in the country itself (with the possible exception of Haryana) still continue to be on outmoded lines, with massive inundation of fields. An Irrigation Expert from the tiny country of Israel is reported to have remarked that our system of irrigation is "several light years behind modern technology"—obviously an exaggeration, though it tells us in no uncertain terms about the current state of affairs. It is in this context that the attempt at modernisation of the system in the Cauvery Delta has to be viewed and it may be said that, it has already proved its worth in the drought of 1976.

While irrigation under canals has already come in for a study for modernisation, though much headway has still to be made in this respect, that under an equally important source, namely, the tanks in the State, has had to suffer from a large scale neglect. When we consider the fact that the 37,400 tanks in the State irrigate a matching area as the canals, the importance of modernising the sources would be obvious. True, periodical maintenance and repairs are carried out to some of these tanks to bring these to standards, repair the sluices, surplus escapes, etc. These, however, at best take care of the safety aspect of the tank—to prevent its breach. These would not obviously contribute in any appreciable extent to the improvement of efficiency of the tanks in the direction of storage, *acreage irrigated per unit volume of water, etc.* It is this latter aspect with which we are primarily interested from the point of view of modernising of the large extent of nearly 23 lakh acres fed by these sources.

Tanks suffer from the following malaise, apart from the possibility of their not being to standards :—

1. Loss of capacity.

2. Insufficient receipt of water through supply channel.

3. Imperfect maintenance of water cources—big and small taking off from the tanks.

4. Wastage of water.

I *Loss of capacity.*—Loss of capacity due to silting is one of those factors over which we seem to have little control and which has come to be accepted as an inevitable evil, which has to be tolerated. Siltation of reservoirs is a worldwide phenomenon and extensive studies have been undertaken to find out means of mitigating this problem. Thoughtless denudation of forests and loosening of the top soil for cultivation purposes in the catchment area of reservoirs, is a major contributory factor to excessive siltation of reservoirs (tanks). On an average, the tanks in the State may be said to have silted up to an extent of 20 to 25 per cent of their original capacity. The capacities of the tanks in the State may be of the order of 200 to 250 tmc. and obviously we cannot think of removing 50 to 60 tmc. of silt even by machinery. The expenditure involved would be unthinkably high: but the suggestion itself would be impracticable from the aspect of lack of space for dumping silt. D.C.R. schemes are invariably accompanied by a raise in the F.T.L. which takes care of the loss in the capacity with the reclaimed land at a higher level in the foreshore of the tank tackling the aspect of foreshore submersion. There has, however, been no feed back of information on the realisation of benefits from the Desilting-*cum*-Reclamation schemes already undertaken. Such a study may be expected to be useful and interesting. Of late, there appears to be a resistance from the foreshore ryots of tanks for dumping the soil on their land. Surprisingly, in a few cases, the soil has been found to be unfit for raising wet crops. Added to this, the in-built restriction in the working season leading to a forced idleness of the machinery adds to the cost of such schemes. Raising the F.T.L. may prove to be the only feasible solution if the foreshore area which gets submerged thereby is not valuable and could be acquired. In the case of system tanks, the problem may not be so acute, in view of the guaranteed supply from the source. There are cases of many system tanks with their foreshore encroached upon heavily, but which, despite this handicap function as effectively, as if there were no reduction in their holding capacity. Thus raising the F.T.L. may be tried in the case of non-system and individual tanks initially. The approach to such problems in system tanks has to be on different lines like, ensuring sufficient flow from the sources, etc.

Reduction in the rate of further siltation depends on the success of methods adopted in preventing the precipitated rainfall from carrying away top soil. Planting of trees in the catchment area of rivers has been suggested, but putting this idea into practice bristles with problems. This can be attempted only where the catchment area is poramboke, like Government-owned forests, etc. Contour bunding is another solution. Again, we have to see to what extent a ryot will be prepared to put up the cost for such innovation to prevent his top soil being washed away, what with the average holding being very low. Also, the farmer in Tamil Nadu and in many other States is not particularly known for his keenness in adopting himself to modern technology. This may, however, be tried in the case of large holdings and through co-operative effort in other cases, after intense propaganda. This method holds out the largest promise for prevention of top-soil erosion.

In the absence, or even delayed action of both the above remedies, which may be classified as long range plans, we are forced to live with the problem of prevention of silt carried by rivers from entering supply channels to tanks. Since, however, silt which enters the river has necessarily to be disposed of somewhere, the aim can be only to go on shoving the downstream wherever feasible, without allowing it to enter the offtakes. This problem has to be studied in great depth and the advantages in a mutual consultation with other institutes of Hydrology cannot be ruled out. In this regard, the Symposium on "Siltation of Reservoirs" being held by the Central Board of Irrigation and Power in the first week of March will be particularly relevant.

II. *Insufficient receipt of water through supply channels.*—The possible causes are: (1) heavy siltation in the upper reaches of a channel leading to a substantial reduction in drawal (2) heavy siltation in front of an anicut, leading to water overflowing the anicut, without sufficient head being available for drawal through the offtake channel, (3) encroachments in the supply channel leading to reduction in capacity and (4) unauthorised tapping in the supply channel.

Aspects enumerated in 3 or 4 above are administrative features, capable of comparatively easy solution. Anicuts form a good barrier for catching silt and the few sand vents provided do not meet with the requirements for discharge of silt. With meagre supplies in our rivers, we can hardly afford to operate the sand vents as frequently as we would like to. Regulators have the advantage of a much lower sill right along the width of the river and are found to function much more effectively than anicuts. Periodical flushing even since in 5 or 6 years, would help in heading up water in front and the drawal of water into the canals can be increased.

III. *Imperfect maintenance of water courses.*—Whatever be the capacity of a tank to irrigate, it is invariably classified as a "Minor Irrigation" source. There are many tanks in the State, each irrigating over a few thousands of acres. The Veeranam Tank in South Arcot District holds the pride of place irrigating an ayacut of 46,000 acres. Tanks irrigating above 100 acres are under the control of the Public Works Department for the purpose of maintenance—covering both routine and special repairs, while in the case of those feeding less than 100 acres, the special repairs alone are done by the Public Works Department. In all cases, however, Public Works Department has no function beyond operation of sluices in the tanks. Channels taking off from these sluices, however big they be, are not maintained by them, with the result that those channels, some of which irrigate a few thousands of acres—have fallen into disrepair frequently with over-sized sections, resulting in uncommandability of the ayacut. Farmers are forced to resort to formation of korambus. If the existing regulations and mamool practices handed down through the ages, do not permit of water management by Public Works Department in the case of even big tanks, it would be necessary to take over at least these big channels and maintain them in a trim condition. Investigation of the channels taking off the Wallajah Tank in South Arcot District has indicated that the expenditure involved in remodelling, including bringing to standards—11 channels taking off from the tank is approximately Rs. 97 lakhs. A typical L.S. and C.S. of one of the channels enclosed with this note would indicate that, these channels suffer from all the defects enumerated above. Obviously, the farmers cannot be expected to put up this cost.

Lining of channels for the purpose of saving on seepage losses is familiar. Lining can also help maintain the channel section over a much longer period than an earthen section. Naturally, the economics of such a programme have to be satisfying.

IV. *Wastage of Water.*—There is a line of thinking that there is no wastage of water in tank irrigation, that the farmers are really not that foolish to waste precious water and that even if there be any wastage, it will be regenerated, and flow down to the lower tanks in the system and

that lining of irrigation channels, especially in non-porous soils, is uncalled for. There is force in this argument, but it would also lead to a complete shut-down of all further activities on the irrigation front, so far as modernisation of irrigation is concerned. Have we not benefited greatly by the modernisation of the Cauvery Delta irrigation, where probably these arguments will apply with equal force? Have not the World Bank Team insisted on lining water courses down to the 150 acre limit in the case of the Periyar System? Can we say that we have attained a stage where it is just not feasible to increase the productivity of water any more and that the efficiency of water management in tanks is at its peak? Our intention is to take a positive view of the modernisation aspect. We are driven to the imperative necessity to save water and increase its productivity. How best to achieve this, is the problem and the solutions should be adaptable to implementation. Some of the lines on which we can probably take action are given below:—

1. The irrigation season starts with the allowance of water for raising seedlings. The usual practice is to flood all the fields raising the seedings however, in only a few of them. The flooded fields are puddled, but before the time of transplantation, these fields go on getting a continuous supply of water. It would be useful to have a Central Seedling farm in every village, where seedlings of good strains are raised and these could be made available to the farmers. The advantages of such a system are obvious—less consumption of water, seedlings of good strains raised under proper technical supervision, over all saving in labour, etc. The village Panchayat which control the distribution of water from a tank should be in a position to clamp down this discipline in agricultural practice. Certainly, an attempt should be made to do so in the case of a few Panchayats as a beginning. With the separation of the requirements for seedbeds and puddling, saving in consumption of water should be feasible.

2. After transplantation the fields are usually kept in any inundated condition for a good length of time which depends on the period of crop. However, during turn systems, introduced in periods of drought, it is generally not found feasible to have standing water on the fields and the method of alternate wetting and drying is forced to be introduced when it is also seen to that the fields do not get dried up to the point of the soil cracking up. This method has not been found to affect the yield. Can we not go in for such a process of irrigation even during normal years?

3. Not all channels run through "water tight" nonporous soil. The porosity of soil is itself a varying factor and the degree of porosity can always be established. Testing of soil samples from channels may be undertaken and the economics of lining the channels with a view to saving the seepage water can be worked out. Membrane lining may be considered, to bring down the cost.

4. The case of Penukondapuram Tank in Dharmapuri District is a typical one of wastage of water. A contour canal taking off the Penukondapuram tank (capacity 148 M.cft.) and running for a length of 7 KM feeds an ayacut of 416 acres. There are 13 sluices in this channel, feeding ayacuts ranging between 3 acres and 83 acres. All the sluices, irrespective of the acrage, are provided with 6 inches pipes with no further restriction in ventway and none of the sluices has any regulating arrangements. Even with one filling of the reservoir, the duty works out to a ridiculously low figure of 2.8 acres per M.cft. If the number of fillings realised is more than unity, as is quite likely, the duty will be still less. True, such low duties may prove to be the exception than the rule, but it is certainly a pointer to the fact that there is indeed a vast need for an examination of such aspects.

5. The following extract from the report of the Irrigation Commission will be relevant:—

"We were greatly impressed by the experimental water management carried out successfully in the village of Siddhamalli within the Cauvery Delta. About 160 hectares of land belonging to 21 farmers had been parcelled out into 0.4 hectare plots, each of a rectangular shape. In place of the irregular, zig-zagging field bunds, narrow and straight bunds, enclosing each rectangular plot, have been formed. Instead of the field to field irrigation which was previously done water now reaches each field through field channels along the boundary of each plot. The improvement in the efficiency of irrigation and drainage has increased production by about 0.62 tonnes per hectare. The area of double cropping has increased...... "

It is to be noted that the above experimental farm has been located in private lands belonging to 21 farmers. Can we not extend the same experiment to many other Siddhamallis in the State?

6. The following report in a daily under the caption "Research on Water Use in Madurai District" is encouraging:

"The Tamil Nadu Agriculture Department will be implementing shortly a Rs. 12 lakh project for Operational Research on Water Management in Madurai District, the first of its kind to be taken up in the State.

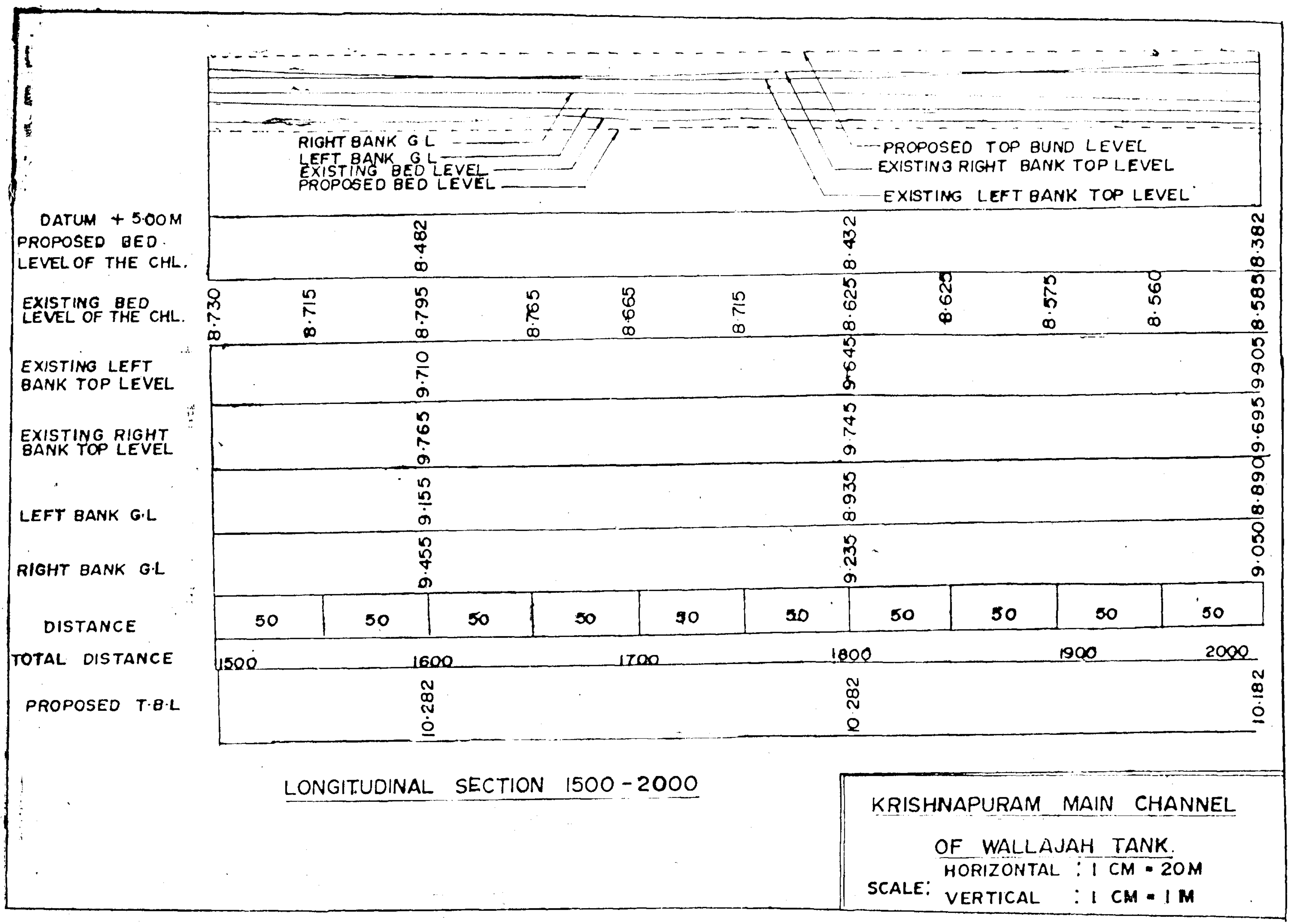
The three-year project which is Centrally sponsored, will be operated in a compact block of 400 hectares in the Periyar River Command Area. It will work out methods of water use which can maximise production per unit of this vital input.

The crop pattern in the Periyar is mostly paddy—oriented. Besides investigating the scope for reducing the quantum of water used for this crop, the possibilities of growing other crops, which can lead to higher productivity per unit of land and water and ensure better return to the farmer, will be explored under the project.

Studies will also be made on percolation of water in the field and seepage in transit from canals, and the timing of irrigation for different crops.

The Department has plans to take up massive water management programme for irrigation tanks in the State and is now working on formulation of this Project to ensure best utilisation of this source on command area development basis".

The basic approach is to use less water and conserve the available quantity. This calls for certain changes in the methodology of irrigation practices and even if a saving of 10 per cent in the consumption is achieved, it would release about 40 tmc. for expansion of existing irrigation.


RIGHT BANK G L
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EXISTING BED LEVEL
PROPOSED BED LEVEL
PROPOSED TOP BUND LEVEL
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DATUM + 5·00M
PROPOSED BED LEVEL OF THE CHL.
8·482
8·432
8·382
EXISTING BED LEVEL OF THE CHL.
8·730
8·715
8·795
8·765
8·665
8·715
8·625
8·625
8·575
8·560
8·585
EXISTING LEFT BANK TOP LEVEL
9·710
9·645
9·905
EXISTING RIGHT BANK TOP LEVEL
9·765
9·745
9·695
LEFT BANK G·L
9·155
8·935
8·890
RIGHT BANK G·L
9·455
9·235
9·050
DISTANCE
50
50
50
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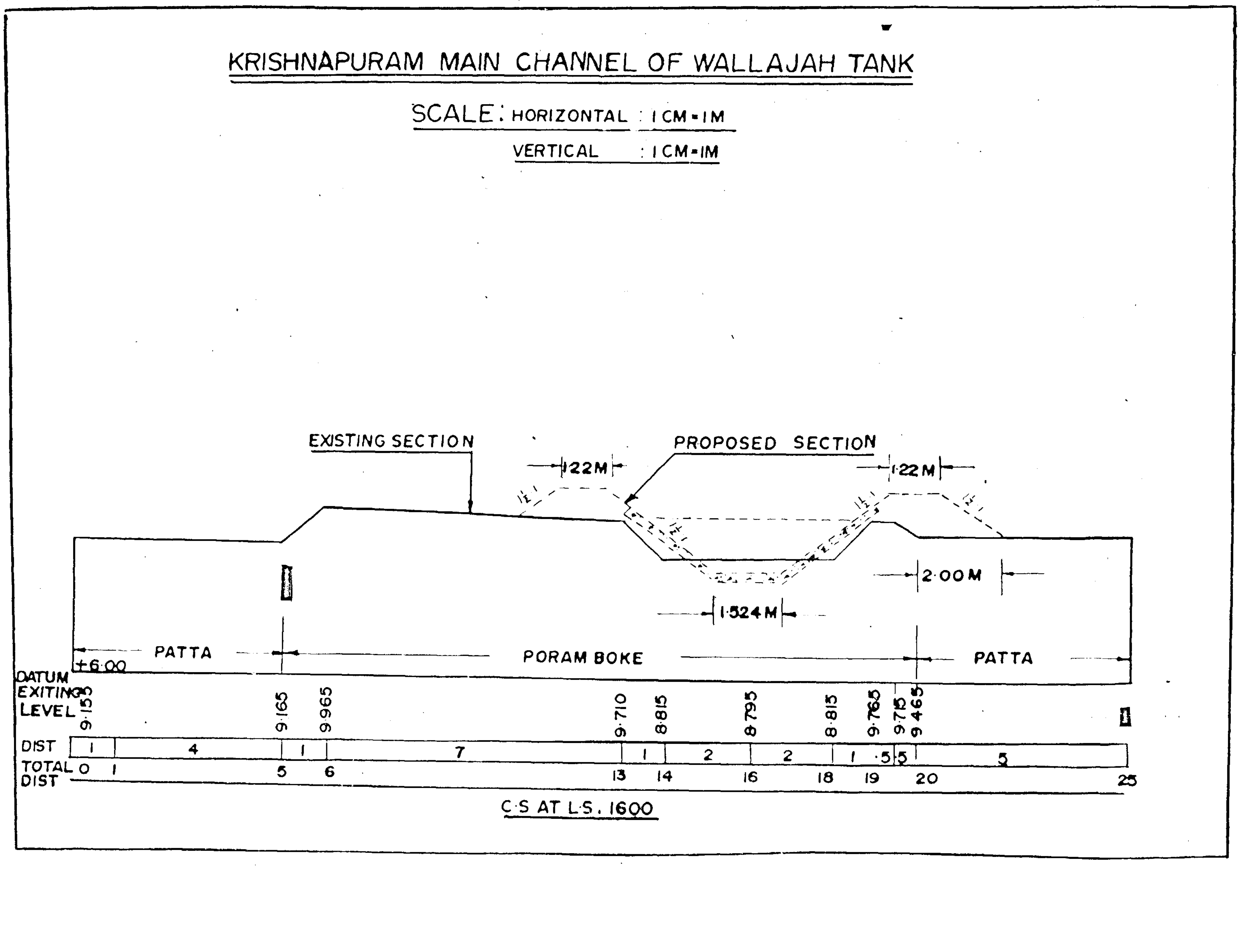
50
50
50
50
50
50
TOTAL DISTANCE
1500
1600
1700
1800
1900
2000
PROPOSED T·B·L
10·282
10·282
10·182
LONGITUDINAL SECTION 1500 - 2000
KRISHNAPURAM MAIN CHANNEL OF WALLAJAH TANK.
SCALE: HORIZONTAL : 1 CM = 20M
VERTICAL : 1 CM = 1 M


KRISHNAPURAM MAIN CHANNEL OF WALLAJAH TANK
SCALE: HORIZONTAL : 1CM = 1M
VERTICAL : 1CM = 1M
EXISTING SECTION
PROPOSED SECTION
1·22M
1·22M
2·00M
1·524M
PATTA
PORAM BOKE
PATTA
DATUM +6·00
EXITING LEVEL
9·15
9·165
9·965
9·710
8·815
8·795
8·815
9·765
9·715
9·465
DIST
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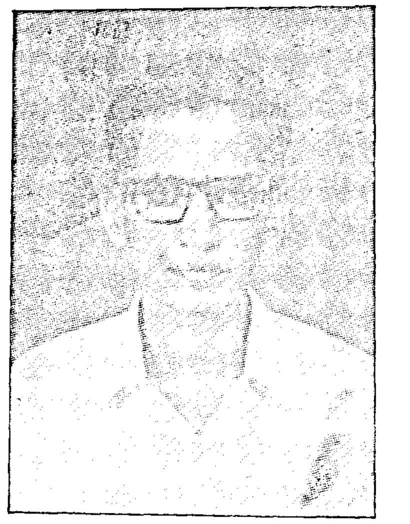
MODERNISING VAIGAI CHANNELS SCHEME—A MAJOR SCHEME IN TAMIL NADU IN THE IRRIGATION SECTOR

by

By Er. C. G. Jayaraman, B.E. (Hons.), M.I.E.

Special Officer (Cauvery Valley Development.)



Preamble.—Almost all the available water resources in Tamil Nadu have been harnessed for irrigation and there is little scope for new river valley projects of large magnitude. Hence greater attention is to be given to modernise the old irrigation systems to ensure equitable distribution of available waters, economic use of water for irrigation and extend the benefits of the saving in water to new extents wherever possible. During the 1960's several old irrigation systems like the Cauvery Delta System Periyar Vaigai Irrigation System and the Old Vaigai Channels were considered for modernisation and investigation taken up. Of these the Modernising Vaigai channels scheme has been sanctioned and taken up for execution.

Details of the Scheme.—The brief details of the scheme are as below:—

The Vaigai River between Peranai in Madurai District and the Ramnad Big Tank in Ramanathapuram District feeds by its flood flows. 476 tanks through 115 channels on either side, benefitting an extent of 1,37,117 acres. Most of these channels do not have control structures at the offtake point which results in unequal distribution of flows. Due to this unsatisfactory arrangement there is a gap of 13,900 acres in the registered ayacut. The rest of the ayacut also is not able to get assured and equitable supplies.

To ensure equitable distribution of the flood flows. to these tanks. the Modernising Vaigai channels scheme was prepared in 1964 and was sanctioned by the Government of Tamil Nadu as a Plan Project in 1968. The scheme contemplated the construction of two Barrages across the Vaigai River one at Virahanur 6 KM east of Madurai and another at Parthibanur near Manamadurai 48 Km below the first barrage. Main canals taking off from these barrages on either side will feed the existing supply channels leading to the tanks. Thus the construction of two barrages and four main canals are involved in this scheme. The existing supply channels will become branches of the new Main canals and the branch channels will be provided with head sluices. Bridges and other cross masonry works are provided all along the four main canals totalling in length to about 170 Km. Between Peranai and Virahanur there are 17 channels and most of them draw, supply satisfactorily now and only control structures at the head is proposed under this scheme. The capacity of the new main canals are necessarily large as they have to draw the flood waters and fill up the tanks within a few days. A new feature viz flood carriers is introduced in this scheme by keeping some of the major supply channels to continue to draw from the river during floods by suitable cross masonry works so as to avoid the Main canals becoming unduly large and uneconomical. Whenever the stored waters are released from Vaigai reservoirs to supplement the storage in the tanks, these flood carriers will also receive supply proportionately through head sluices provided in the Main canal.

The execution of the scheme was commenced in 1969 by Vaigai Modernisation Division, Madurai but it gathered momentum during 1970-71 after a second division was formed at Paramakudi for execution of works in Parthibanur area. A third division was also formed in 1974 to concentrate on the works of Virahanur canals around Manamadurai. The entire scheme is now nearing completion. The parts of the scheme as and when completed were put to beneficial use from 1973 onwards. During November 1976 supply was allowed by releasing water from Vaigai Dam which was equitably and successfully distributed to all the tanks including the Ramnad Big Tank. The scheme is estimated to cost Rs. 823 lakhs on completion.

The salient features of the two regulators are as below:—

	Virahanur Regulator.	*Parthibanur Regulator.*
Design flood discharge ; ..	1 08 000 cusecs	1.30 000 cusecs
No. of vents of the regulator ..	18	25
Clear span of vents ..	40 0″	40 0″
Height of Shutters	6 6″	6 0″
Width of service roadway over the regulator	12 0″	12 0″
Sill level of regulater and Head sluice ..	390 50	187·00
Sill level of scour sluices ..	387·50	185·00
Left side head sluice —		
Discharge	300 Cusecs.	1,700 cusecs
Number of vents	2	5
Size of vents	6 0″x5 0″	12 0″x6 0″
Size of Main Canal at head ..	24·0″x5·0″	90 0″x6 0
Length of Main Canal ..	31Km.	45Km

	Virahanur Regulator	*Parthibanur Regulator.*
ight side head sluice—		
Discharge	700 cusecs.	1,800 cusecs.
Number of vents	3	5
Size of vents	8′0″x6′0″	12′0″x6′0″
Size of Main canal at Head ..	44′0″x6′0″	90′″x6′0″
Length of Main canal ..	46·6	43·3
'cop sluices (Left Side)—		
Number of vents	2	5
Size of vents	6′0″x5′0″	12′0″x7′0″
cour sluices (Right Side)—		
Number of vents	3	5
Size of vents	8′0″x6′0″	12′0″x7′0′

The two regulators were declared open on 15th November 1975.

Salient features of construction.—Construction of Parthibanur Regulator was commenced in 1970. It was situated in a remote locality in the backward area of East Ramnad District and trained labour was not available. Contractors did not come forth to take up the works. During 1970 and 1971 two major contractors came forward to take up the works after repeated tender calls A few small contractors were also persuaded to take up works. The canal excavation was done through job workers, with imported labour, from the Dindigul and Nagercoil areas who are trained in earth work. They did not find the schedule of rates attractive and the works could be pushed through only with great difficulty. The soil in the canal area was mostly clayey of a heavy type which is difficult to excavate both when it is moist and when it is dry. During the drought of 1974 local labourers also came forward to earthwork and hence the canal excavation could be completed to a large extent. The canal alignment was generally having difficult access and completely in-accessible in rainy season as the village roads became slushy and this made conveyance of materials for the cross masonry works very difficult.

The Virahanur Regulator is situated close to Madurai City and hence there was good response from the contractors to take up works. For both the regulators roads were formed by the department so that the works can continue uninterupted throughout the year. In the case of the left main canal of Virahanur, the access was difficult which affected the progress of works. In the Parthibanur and Virahanur Regulators sites labour colonies were established by the Contractors and departmental workers were housed in the camp colony constructed at site. Temporary structures were put up for store sheds and for the site workshops.

Economies were effected in the construction of regulators by adopting CC 1 : 4 : 8 mix for the solid apron in place of CC 1 : 3 : 6 usually adopted for such works. High centering on the river bed was avoided for the R.C.C. counter weight beams which were precast on the service Road bridge and hoisted to the position by serange using devicks and chain pulley blocks. Neoprene Rubber bearings were used for the bridge in place of the costly conventional metal bearings. In Parthibanur Regulator stone and broken metal had to be brought from a long distance (54 Km) and hence the talus was formed by casting sand cement blocks, in site using sand available in the river bed.

The operating platform of Parthibanur Regulator was supported by steel trusses; whereas in the Virahanur Regulator, which was taken up later, steel girders with hand rails were adopted which is more elegant in appearance.

The energy dissipation arrangement on the downstream of both the regulators was provided in the form of a sunk stilling basin. In the Parthibanur Regulator one row of baffle blocks were provided in the stilling basin. The peak period of construction is 1971 to 1973 in the case of Parthibanur Regulator and 1973 to 1975 in the case of Viranhanur Regulator.

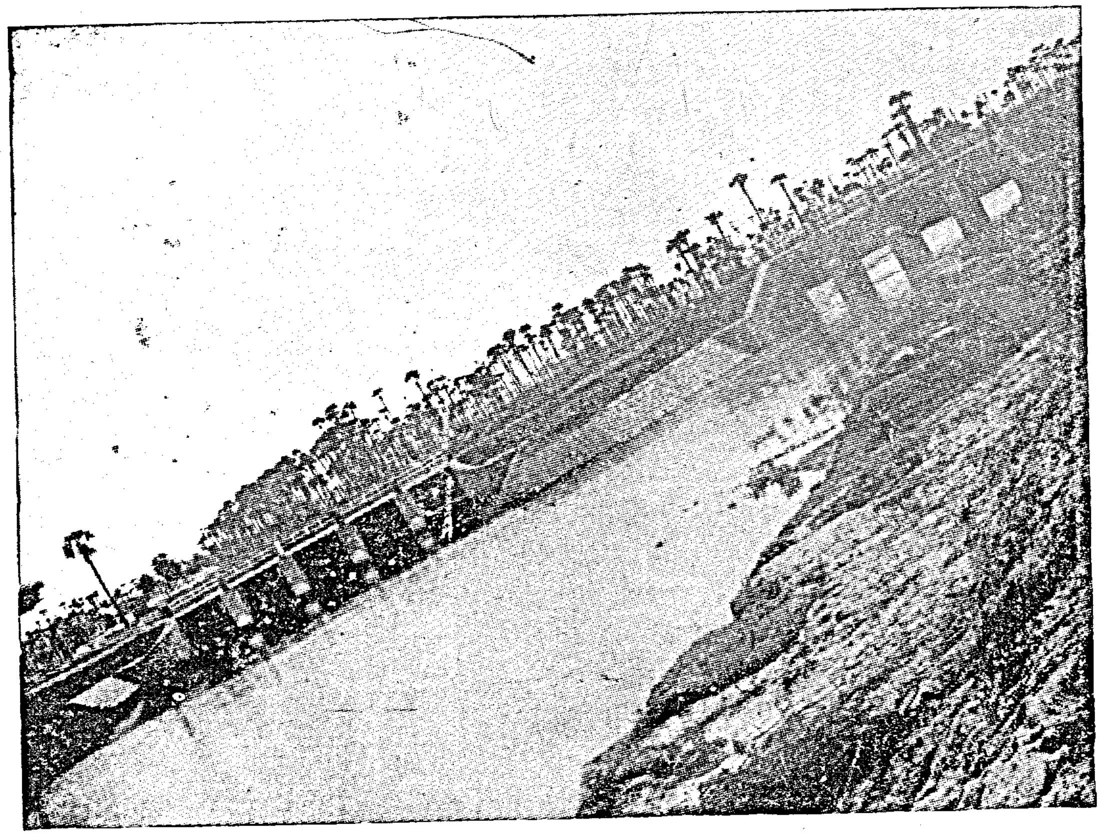
The upstream and downstream cut off walls with C.C. 1 : 3 : 6 in the Regulators were designed to be taken to a depth of 14′ 0″. However, in Parthibanur Regulator the deep sandy course was confined to the Right Margin and in the other portions hard shale like structure was met with at shallow depths and the cut off walls were not taken down to the full designed depth but were stopped at the hard strata and keyed into the hard strata for about 2′. The concreting of cut off walls were done in open excavated foundations with shutterings wherever necessary.

The dewatering problems were quite formidable in both the regulators but were managed by installing a large battery of pumps. The problem was more acute in Virahanur Regulator where the entire foundation was sandy. A high flood occurred during the construction of Parthibanur Regulator on 18th December 1971 when the works were in full swing in the left half of the river. But the earth coffer dams provided around the work area was sufficiently strong and high and damages were averted.

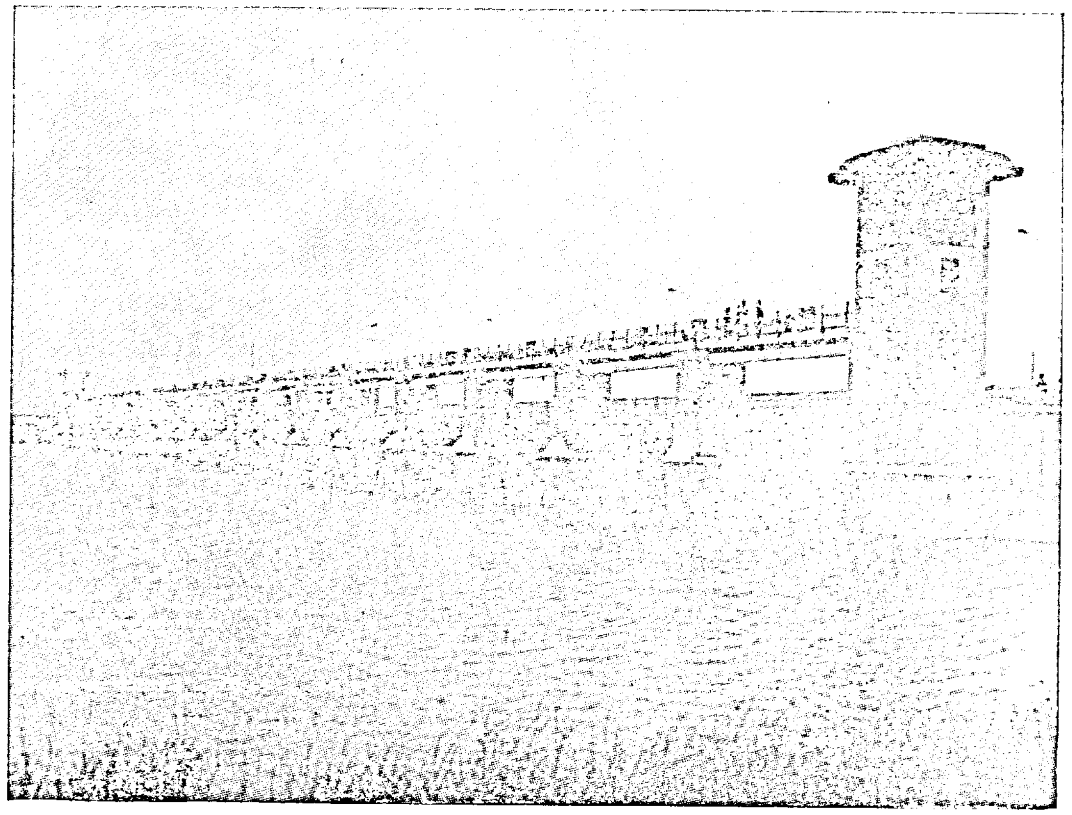
In both the Regulators sites beautification of the area and formation of parks, lawns and garden have been taken up as the place are attracting visitors and tourists.

The cost of the two regulators at Parthibanur and Virahanur is about Rs. 1.30 crores and Rs. 1.00 crores respectively.

The scheme is expected to be completed in all respects next year affording full benefits to the large ayacut in the drought prone areas of the State.



Head Sluice and Canal Regulator at KM 22·0 of
Left Main Canal of Parthibanur Regulator.



Virananur Regulator

DEEP CUTTINGS IN PROJECT WITH REFERENCE TO TUNGABHADRA AND MANIMUTHAR PROJECT

by

* THIRU H. S. VENKATARAMU, B.E.,

1. *Why rock cutting will be necessary.*—During the course of investigation of alignment of alignment of a canal, all the alternative for canal excavation, viz., through contour and through short straight cuts, etc., will be investigated. Rock cutting will be resorted in canal alignment only during exceptional circumstances such as to avoid canal passing through any Villages or built up area or valuable Mango and Coconut grooves etc., and the straight cut may be much costlier.

2. *General.*—In this paper the general difficulties and the modes adopted for counteracting these in deep rock cuttings are dealt with. Detailed statistics and the figures furnished are approximate and are by memory only.

Before tackling any deep cutting the section should be well designed and finally settled before the excavation is taken up as otherwise a widening of the section due to change in design will result in insufficient berm involving rehandling of huge quantities of excavated spoils. This has been one of the common troubles met with in all deep cuttings especially where work done is part by part by petty job workers. The deposition of spoils should be well planned and necessary land, sufficient if the spoil is deposited for a height of 15 to 16 feet should be acquired. In assessing the quantity of spoils, 40 per cent excess should be adopted as otherwise the bank will be insufficient when the spoils are deposited pelmel. In deep rock cuttings measurement by stacking is not workable as the quantity of rock is huge and as the measurement is not first and final there is always a chance of fradulent practice in stacking.

It is always economical to use manual labour for top soil excavation where hard soils are met with at top levels, machinery cannot work properly in soils beyond hard gravel and in soils mixed with boulders. In cases where clay is met with for considerable depth and the quantity involved is more than a thousand units, it may be quite economical to use earthmoving machines for top soil excavation. In the Kondanayakanahally deep cut in Tungabhadra Power Canal M (5|5.615 to 6|7) the first 4 furlongs had 10 feet to 12 feet depth of clay and machines were available at hand and hence dragline excavation was employed for excavation of Top soils. Except for the unworkability in the top soil rates, no serious difficulties are usually encountered. But below a depth of 12 feet the normal earthwork rates adopted are not workable and a percentage increase in rate for every additional 3 lifts seems desirable

3. *Alignment and Levelling.*—Check level Benchmarks should be established every 500' about 200' left of the central lines and these should be specially guarded without damage till the end of the project. When rockwork is started reference marks should be left on the sides where damage due to blasting is not likely and for every six feet depth of excavation the centre lines should be checked by marking the centre in 2 or 3 places when reference to the marks left at top by dropping plumb bob and the rest of the line aligned, unless a proper check is exercised on checking of alignment a straight line at top may result in a zig zag line 30 feet at bottom for checking up the central line, a 4 to 6 feet height of rod fixed to weighted base will be of much use so that these can be kept in position and central line checked and afterwards removed prior to blasting. Levels can be marked on the sides of the cutting as the work progresses every 6 feet in height and about 50 feet apart and once these are correctly checked by the concerned Sub Divisional Officer measurements can be based on levels derived from these marks by string measurements. However it is preferable to check the bed levels independently just before the bed level is reached.

4. *Preliminaries to Blasting.*—When once the rock is met with heavy blasting is to be invariably adopted, as everybody knows blasting consists of 4 operations (1) drilling the holes, (2) charging the holes with blasting materials, (3) blasting and (4) breaking these into smaller bits. Out of these the last operation is invariably done by manual labour and drilling of holes can be done economically by using a compressor with Jack Hammers. A jack hammer working for 8 hours can drill about 80 to 100 per shift of 8 hours in hard rock whereas 1 pair of hand drillers can only do about 8 to 10 Rft. per day. Usually more labour cannot be employed in rock cutting as the space available for work is limited as drilling holes and blasting rate cannot cope employed in rock cutting as the space available for work is limited as drilling holes and blasting rate cannot cope up with the rate of removal of debris. Hence by employing jack hammer and compressors the rate of progress can be increased by 4 to 5 times than that of manual labour. The only disadvantage is that in case of failure of compressor the large organisation of labour which will be required for work will go idle. This can be to a great extent eliminated by having one spare compressor for every 2 compressors as stand bye. One compressor and 4 jack hammers will be able to do about 20 units in hard rock and more than 40 units in soft rock

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requiring blasting per day. One more precaution to be guarded against is running short of Jack hammer rods. There are two types of rods one with drill bit forge into the rod. The tip is made up of carbide steel and if properly used it can drill about 1000 Rft. in hard rock. The bits will have to be sharpened by a grinder as they get blunt. In case of soft rock the life of a rod can be easily 4 to 5 times. The other type of Jack hammer rod is called the diamond type. This has a diamond shape drill bit which is to be screwed on to the drilling rod. This always requires a costly shanking and a drill sharpening machine to be used in conjunction with this and hence this process is more complicated for common use in out of the way places.

5. *Blasting Operations.*—The common explosives used are (1) Gun powder (2) Gelatine. Wherever the quantity of blasting work is limited and in dry conditions the most economical explosives is gun powder. Gun powder is a mixture of Pottasium nitrate, Sulphur and Charcoal mixed in painted proportion.

This can be prepared locally with experienced job workers possessing a lice or obtainable in 1 lb. packets from Messrs. I.C.I. Limited; The holes drilled in rock is first well cleaned and sufficient quantity of gun powder is put in fuse coil (Black) is introduced into the gun powder about 2 inches inside the powder. On the top of this, dry earth is put into thickness about 6 to 9 inches and well rammed by using a ½ inch dia. brass rod and a wooden mallet. Care should be taken that no iron tool is used for tamping as most of the common accidents are caused only on account of this cause.

(*a*) *The use of Gun Powder.*—Gun Powder is a mixture of Pottassium nitrate, Sulpher and Charcoal mixed in patinted proportions. Its use is limited as in wet conditions met with in deep cuttings the gun powder gets wet and hence it cannot work.

(*b*) *Use of Gelatine.*—Gelatine is obtained in 4 inches cartridges or 8 inches length cartridges (4 Nos. per lb.) Gelatine can be blasted only by using a detonator and a fusecoil. The ordinary black Bull brand or Thistle brand fusecoil cannot be used in wet conditions. Hence a white countered water-proof fusecoil is to be used. The fuse which is obtainable in coils of 24 feet length is cut into sizes of 3 feet to 4 feet depending on the depth of holes to be fired. A fusecoil should always be cut only by using a pen knief and not cut in crude ways by striking between two stones. One of the accidents in Manimuthar Canal was only on account of this reason. A fusecoil, one end of which was in the bag containing gun powder when cut by a stone, caught fire due to the splint fire which communicated to the bag through the fusecoil which took fire and the man got a very bad burn and died in the hospital.

The cut fuse is then introduced into the cup end of the detonator and tightened by using a crimber (a special aluminium plier). Bad practices like tightening them by teeth or crude instrument should scruplously be avoided. First the required number of cartridges depending on the depth of hole and nature of rock are put into the hole. The last cake should be the one containing the detonator. On the top of this dry sand is poured in and the hole is closed. No special tamping is necessary in case of gelatine. In case of under water conditions, water iteself acts as the damping material.

(*c*) *Firing the holes.*—The length of fuse that is selected for each hole depends on the time required for escape to a free zone. Generally holes inclined at one direction are to be taken at a time. About 10 to 15 holes are taken at a time and the naked end of the fuse is set fire to often taking all necessary precautions as per M.D.S.S. and the blaster should escape in a direction opposite to the direction of the holes. He should count the number of holes while setting fire and count the No. of blasting sounds to make sure that there are no misfired holes.

(*d*) *Misfires.*—Misfires are usually due to the following causes (1) Fuse being of a unnoticed deteriorated quantity due to dampness, etc. and hence the fire not reaching the detonator. (2) Fuse being cut into pieces by a neigbouring blast before fire reaching the detonator (3) Cleaning of the detonator before introducing the fusecoils not being proper.

When the number of explosions do not tally with the number of holes fired immediately the misfired hole should be located. Care should be taken before going near that all explosions have been completed. To ensure this, it is always preferable to give a time lag of 10 minutes before going near the blasted holes. Immediately, the misfired holes should be well marked and another hole drilled three inches away from this and set fire to when this charge will also separately explode.

Some of the accidents have occured hand drills trying to deepen the existing misfired hole.

(*e*) *Electrical Blasting.*—In case of an electrical blasting no fuse coils are required but electrical detonators are to be used. Electrical detonators contain insulated wires at their end. The detonators are introduced into the cartridges as in the case of ordinary blasting. The wires from each of the holes are connected in series to electric lead wires about 500' in length which are connected at the other end to the exploder. The series connections are connected to an ohm. meter to check whether the connections are proper. After all the preliminaries are complete and people cleared from the blasting zone the exploder is charged. All the holes explode together with a single sound giving out a good blast. In case of electrical blasting there is no chance of misfire. The only disadvantage is electrical detonators was costing about 65 np each whereas the cost of ordinary detonator only about 10 np.

6. *Mucking.*—Mucking in the ordinary depths is usually done by manual labour. Beyond a depth of 25' to 30' in rock, mucking with manual labour will not be economical. Some type of lifting device is found advantageous. In Tungabhadra Canal a rotating Jib crane was employed at one end and a loco ramp was used in another end. In Manimuthar Project 2 Nos of

electric winches were employed. The advantage of these winches will be fully realised when bed level is reached in the lowest portion of the ramp. This will give two working faces for the last 10 to 15' layer to be tackled. A Loco ramp requires a gradient of 1 in 30 whereas a winch ramp can work in a gradient of 1 in 4. Hence forming of a loco ramp in high cuttings will be very costly especially where the major portion of the cutting is in rock. This is very economical in cases where the depth of cutting suddenly comes down over a distance of 500' or 600' where the loco can be easily employed from one end. An ordinary winch with 3,000 lbs. capacity can pull up about 60 trucks the cutting is in rock. This is very economical in in a shift of 8 hours or approximately 9 units (solid measurement). In the initial depths the problem will be to do sufficient drilling and blasting to provide sufficient work for the labour. But in the lower depths mucking will be difficult and blasting may get held up if not organised properly.

7. *Dewatering*.—Dewatering presents individual problems depending on the location of each cutting. In Tungabhadra there was the Raya Channel flowing just about 500' away on the side and the depth of the cutting was more 30' lower than the bed of the canal. So naturally most of the Raya Channel water was seeping within into our canal. There was no power available anywhere winthin 3 miles alround. Hence diesel machines were employed. Hence we had powerful 6" x 6" diesel pumps spaced at every furlong and one smaller pump of 3" x 3" used in between them. For transferring water from pit to pit we had small 2" x 2" morrison pumps running on powerline. In case of pumps and other machines in deep cuttings there is always a danger of these machines and accessories getting damaged due to blasting. A blasted stone can hit even at a distance of 600' to 700' away. Hence pumps in blasting zones should invariably kept covered on top by a proper roof preferably G. I. sheets. The front should be covered by masonry walls. Eventhough these items may look expensive at the outset when compared with the protection obtained for the pumps and consequent savings, the amount spent on these on a large work is really a savings as a longer life is assured for the machines. In 40' deep cutting even with the minimum bed width of 15' No. of units per furlong is about 5,000 units. 2 pumps pits may totally cost about 500 to 600 rupees. The extra cost per unit involved will be about 10 np extra. This is at the older rates. The metal suction hoses may be disconnected and removed when the blasting is within 20 M radius. In case of rubber hoses it is desirable to give a winding of coir rope over the entire length.

In Pattangad deep cutting, Manimuthar Project, for length of 5 furlongs we had 2 electric pumps 2" x 2' 2 Nos. Jaeger Diesel Pumps 6" x 6" and 3 Nos. ordinary 5 HP 3" x 3" diesel pumps. In general diesel pumps are costly to operate and the cost of repairs is high, dislocation of work due to pump falling under repairs is frequent. The cost of an electric pump for the same discharge is only half that of a diesel engine for the same capacity. The problem of special storage and supply of fuels including complicated accounting and fear of pilferage is completely eliminated. As rubber hoses constantly get damaged, it is economical to have metal pipe for the suction side in general. Wherever power is easily available electric pumps are definitely cheaper than other types of machinery.

8. *Modes of measuring and payment*.—Normally in deep rock cuttings as soon as top soils are cleared and clear rock exposed, levels should be taken before commencing blasting. Post stacking for checking is not possible due to the following reasons. When huge quantities of rock involving thousands of unit are to be stacked it requires abundant space and acquisition of such large tracts of land for stacking will not be economical. As the No. of measurements are to be taken for intermediate payments and stones from measured stack are always available fraudulent stacks will be a common feature. Hence the rates provided should not include the stacking clause.

The levels are to be recorded in an LF book and the acceptance of contractor obtained in the LF book.

In both the Manimuthar and Tungabhadra Project schedule of rates for rock work in the concerned circle were adopted. In Tungabhadra area the rate was Rs. 30 per 100 Cft. of hard rock and Rs. 22 for medium hard rock with 25 np extra for every lead and lift. The normal labour rate in the area which was mostly imported was Rs. 2 per man and Re. 1 per woman. In Pattangad deep cut of Manimuthar Project Canals the initial rock rate was Rs. 14 per 100 Cft. of hard rock and Rs. 12 for soft rock requiring blasting with an extra of 25 np for every additional lead and lift. The prevailing labour rate was 1.25 per man and 0.63 per woman. Below a depth of 30' these rates were found unworkable and the work almost came to a stand still and a rate of Rs. 18 was sanctioned for all types of rock below 30' in depth. This was unduly advantageous to certain contractors who encountered only soft rock till the end. The recovery rate for Jack hammer holes drilled-departmentally as 25 np per Rft. The present basis of fixing rates arbitrarily based on certain quotation where the quoting man will not have a deposit is not proper. A standard data for rock work should be approved taking into consideration the labour rates, rate of recovery cost of blasting materials per Unit. Any deviation from the data like excess consumption of blasting materials due to restricted space, etc., should be observed over a period and proportional increase of rates sanctioned. Then only these rates for any work can be considered reasonable. The following data can be considered reasonable eventhough it may slightly differ as per local conditions. Leads in deep cutting should be reckoned along the walking path as it is not possible to get up in all places with the plate in M.D.S.S. which takes minor cuttings and embankments to consideration where it is possible to have any number of steps at no cost. I conclude this article with a rough data for rock work which was observed during the work.

For 100 Cft. of hard rock measured in solid—

16 Rft.	Jack hammer holes
2 lbs.	Gelatine
1 No.	Fuse Coil
8 Nos.	Detonators

Loading	Blasting, etc. L.s.
Mucking Labour—	
2 Nos.	Hammer man
1 No.	Man Mazdoor
2 Nos.	Woman Mazdoor

Extra for lead and lift.—One woman Mazdoor can carry 1|3 Cft. at a time and can make 150 trips with initial lead and lift. In addition to this work a deep rock cutting involves hazards for the contractors like accident compensation, which is common in deep cuttings, for which a reasonable percentage should be added to the rates worked out as per data.

To be successful in organising a deep cutting work one should have a fundamental knowledge of mechanical and electrical equipment in addition to the Civil Engineering aspect of it and the major upsets on the work are mostly due to mechanical and electrical failures.

ELECTRONICS IN CIVIL ENGINEERING

by

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1. *Synopsis.*—Review on the use of Electronic principles Civil Engineering instrumentation is made to bring out the different methods adopted and principles involved in the functioning of several electronic instruments, supported by a few examples. Three methods viz. (1) Resistance method; (2) Capacitance method and (3) Induction variation method are dealt with highlighting the salient points.

2. *Introduction.*—Numerous inventions and developments have made it possible for laboratories to be orgainsed specifically for quality control, for Research and for Engineering testing throughout the world. In recent years application of Electronics have become more and more wide spread. Electronic circuitry found its way into Scientific apparatus and allied instruments increasing their reliability speed and versatility and made this world literally a " Small World ".

To the layman and even to many professionals until recently, the term Electronics meant a subject dealing with Radio, Television and more recently tape recorders. As the pace of life increased and Scientists began to think in terms of Micro and Micromicro seconds, rapid development in Instrumentation also followed. One was the development and consolidation of the manufacturing techniques of the transistors, the tiny, non-heating, semi-conductor analogue of the thermionic valve. The transistor initiated research and development of " Micro Electronics " i.e., in to the micro miniaturisation of electronic components enabling the designer to fabricate equipment in less than one-hundredth of the size and weight resulting in enormous saving in power consumption and space. While the advantages of micro electronics in reliability and reduction in volume and weight of complex system are cited most often as justifying the feverish activity in this field, the substantial reduction in costs potentially afforded by technology is the prime mover in obtaining support for micro electronics.

So it goes on, Electronics, a science in its own right has assumed a mushroom growth in the last decade spreading its influence to every aspect of our life. Now the development of new devices are proceeding at such a startling pace the statement that " if it works it obsolete" is often only too true.

Several Electronic instruments are developed to meet the requirements of high-way Engineer, Contractors, Water development specialists and others in Civil Engineering.

3. *Principles and a few Applications.*—In measurement of a physical phenomena by electronic system the transducers form the significant link, which converts the physical effect into Electrical signals.

The electrical properties of a solid material may be affected by external influences such as heat, light, strain, etc. These effects frequently provide a means for sensing the various conditions.

4. *Resistance Variation Methods.*—The electrical resistivity of most material is a function of temperature. In the case of pure metals an increase in temperature leads to an increase in resistivity, attributed to the fact that conduction electrons are impeded in their flow through a metal by thermal agitation. That is how the electrical thermometer works.

In the hot wire anemometer, which utilizes the cooling effect of a moving current of air on a heated wire to cause a change of resistance. This method is well known to the measurement of low air velocities.

Similarly the percentage of humidity can be measured as the Electrical resistivity of substance is reduced when the moisture content of the material increases.

When a conductor is put under mechanical stress it experiences a strain in the direction of the applied stress. As far as the conduction of Electricity is concerned two effects occur. The first is that increase in length and decrease in cross sectional area of the conductor increase its resistances. The second depends on the fact that the strain may effect the crystal lattice pattern and hence the resistivity of the material, this is known as piezo resistive effect.

Based on this principle, the measurement of force acting on any individual beam or on a number of beams of a high tower made up of numerous beams connected in vertical, horizontal and criss cross pattern according to the ingenuity of the designer, can be carried out by affixing strain gauges on the beam, and subjecting the tower to external forces, accurate strain measurement can be carried out. The results of measurement will act as an invaluable guide to the optimum design of these huge structures with economic and effective utilization of material.

Further strain gauges working on the above mentioned principle are used to conduct compression tests, vibration tests to measure strain on the bridges, etc. Semi-conductor strain gauges are opening up the field for the measurement of loads of the order of grams or ounces because of their much greater sensitivity.

5. *Capacitance Variation Methods.*—As an electrical capacitance is such a simple device it would seem to offer an easy solution to many measurement problems. Between the parallel plate of a capacitor the electric lines of force in the centre region are garallel. Movement of the capacitor plates in the direction of these lines of force changes the capacitane inversely as the plate spacing.

Making use of this capacitance variation many instruments are available. In the water wave profile recorder the sensing element of the probe is an enamelled copper wire serving as a small cylindrical capacitor, the capacitance of which is proportional to the depth of immersion.

In measuring twist of huge towers the capacitance variation method is used. The twisting action of the tall structures like Television towers under condition of high wind loading can impair the efficiency of Television link and can have demaging effects on the structures itself. The twist measuring unit consists of a capacitor transducer, in which the moving vanes of the variable capacitor are mounted on the same axis. Thus the twist is converted to a capacitance parameter which in turn may be converted to a variable voltage by means of circuits and can be readily recorded.

Asphalt density recorders can be used by highway Engineers and contractors to make instantaneous measurements and continuous records of pavement density. The sensing capacitor includes one set of capacitor plates directly touching the asphalt. They are the runners that device slides on. The other inside capacitor plates are mounted on the underside of the instrument body at a fixed distance above the skids. The electric field radiate between these two sets of plates and the fixed displacement distance between them determines the depth of penetration of the AC field, affects the sensitivity of the sensor and determines the linearity of the response of the sensor to the test material.

The capacitance variation principle is used in measuring the evenness of the surface, materiel thickness, etc. Equipments are available for the measurement of moisture content by permisivity method.

6. *Magnetic induction and Displacement Methods.*—Whenever a conductor moves relative to a magnetic field an electro motive force is generated. This is the basis for many sensing devices. The basic sensing element in the displacement transducer is a linear variable differential transformer with a magnetic core which produces an out put voltage directly proportional to the mechanical displacement of the core.

The fluid medium where pressure is to be measured is allowed to deflect a thin stainless steel diaphragm held rigidly in a flange assembly. The diaphragm deflection is sensed with a linear variable differential transformer.

The vibration transducer consists of a suspended mass a permanent magnet and coil, when the outer structure is subject to vibrational movement, the suspended mass remains undisturbed, and as the coil moves up and down a signal is generated in the halves of the coil due to changing flux linkage. The out put signal is thus proportional to the velocity of the outer structure at any moment.

A magnetic detector, making use of the change in magnetic flux, is used for testing the concrete namely detecting the location of reinforcement bars in concrete, determining the size and condition of reinforcement bars. Its basic operating principal is change in magnetic flux, likages through test materials.

To find the exact distance travelled in the boat during capacity survey of reservoirs using Echo-sounder instruments are available making use of the magnetic induction Transducers. On this type of instrument transducer operates by the creation of magnetic field of alternating polarity in the immediate vicinity of, the transducer face. This magnetic field in turn produces an electrical voltage gradient in the water which is in motion with respect to the field. This voltage which is sensed by the two contracts on the face of the transducer is directly proportional in magnitude of the velocity of water.

Seismograph type pickup may be used to measure either displacement or velocity or acceleration.

7. *Other Methods.*—There are many instruments working on other electronic principles. Road and airport pavement surface deviations in 1|8" increments are detected by means of the photo electric pick up system. The photo electric pick up counts the 1|8" deflections of the rear differential of a standard vehicle and send the pulse to the counters which store the number of pulses in memory until recalled by the operator for display or print out.

The basis of depth determination during capacity survey by an Echo-Sounder is the fact that sound waves (in practise ultrasonic waves) travel in water at a constant velocity, which means that by measuring the time taken for a sound pulse to travel from the transmitter to receiver the distance between the two can be determined.

To determine the water level in bore wells and other open underground structures water level detectors are available. It consists of a rigid rod mounted on an insulating support and extending down to the level to be detected. The rod is connected to an electronic unit which supplies a small Ac potential to the rod and senses when this is short circuted by the rising liquid.

The resistivity meters are available for gravel or material detection, determination of water table, depth to bed rock are prospecting, etc. It is based on the measurement of the apparent resistance of subsurface materials to electric current.

8. *Concluding Remarks.*—From the review, it can be seen that all the methods are equally important in evolving new instruments to suit our objective. It may

therefore be suggested that whenever a researcher is interested in designing a new instrument for a specific purpose one or all of these methods may be tried in preference to several other methods available.

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SILT STUDY OF PERUMAL TANK

(in Tamil Nadu)

BY

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Synopsis.—Storage reservoirs are created at enormous cost for the economic growth of the nation. The largest quantity stored at the cheapest cost, will give rise to cheap production of power, cheap rate water cess and in turn better return for the capital spent on the reservoir and better economic growth of the nation.

But unfortunately the picture is not as rosy as that. The catchment of the reservoir is generally hilly tracts and the precipitation or runoff flows down the hills at high velocity and its transportation energy is enormous. The water on account of its kinetic energy carries and drags the silt along with it. Wherever the energy is dissipated the silt is deposited. Thus as soon as a reservoir starts functioning, silt and sediments begin to deposit and thereby reduces the capacity. This problem of silting up of reservoirs is so enormous, that it creates a loss of many crores of rupees merely by depreciation in investments by reducing the usefulness for which it is designed for.

The magnitude of the problem of silt accumulation in tanks and reservoirs, the sources of irrigation and hydro-electric generation system is being so keenly felt that regular periodical study has been found essential. Silting besides reducing the impounding and flood moderating capacities of the tanks and reservoirs strikes at the very basis of the original calculations and tilt out of balance our food production programme. In order to device ways and means to combat silting up of reservoirs and tanks, a thorough knewledge of type of rate of silting is quite essential. It has been observed that silting reduce the capacity of most of tanks and reservoir by 1 to 5 persent every year in Tamil Nadu.

Introduction.—Government of Tamil Nadu after considering the importance of the problem, have sanctioned a scheme to do the silt survey of five major tanks and reservoirs in the State. These tanks have been selected in such a way as to give wider study of silting problems in the State. One such tank is Perumal Tank in South Arcot district.

In this paper, it is proposed to discuss the silt survey done in this tank during 1975.

2. *Perumal Tank*—2.1. *Location and Access.*—Perumal Tank lies in Southern half of Cuddalore Taluk in South Arcot district and runs North East to South West for a length of 16.2 km. There is a regular tank bund in the Eastern side for the full length of tank—*Vide* Plan No. 1.

2.2 *Monograph of the Tank.*—Originally this tank was rain fed tank with a catchment of 559 sq. km. of which 368 sq. km. is intercepted by another tank above by name Wallajah Tank—*Vide* Plan No. 2. But in later year i.e. in 1936 to stablise the ayacut under this tank, the irrigation system of this tank has been attached under Sethiathope Anicut System. The annual rainfall over the catchment is in the order of 122 cm. most of which is due to north east monsoon. There are eleven supply sluices from this tank. The present ayacut under this tank is about 9000 acres and the main crop is paddy.

2.3. *Surplus Water.*—This tank has one natural bye-wash and two weirs. The length of the weirs are so designed to discharge the flood discharge.

3. *Silt Survey and Organisation*—3.1. *Objects.*—The main object of conducting silt survey in a reservoir is to determine the volume and distribution of sediment accumulated either during the total period of existence of the tank or between the two consecutive surveys. Such survey besides enabling an assessment of the probable life of the reservoir provides a fair idea of the distribution of silt at various elevations and also enables periodic corrections of capacity curves.

3.2. *Survey Work.*—Different methods of field operations available.

1. Levelling Operations.
2. Echo-Sounding Method.

The entire work in silt survey can be broadly classified into 3 different heads of works.

1. Reconnaissance and preliminary preparation,
2. Field operation and
3. Office work.

3.2.1. *Reconnaissance and preliminary preparation.*—Detailed reconnaissance of the water spread and the supply sources of the tank was initially undertaken by

1 * Superintending Engineer, P.W.D., Designs Circle, Madras.

2 † Deputy Chief Engineer, P.W.D., Irrigation and Designs, Madras.

3 ‡ Executive Engineer, P.W.D., Gauging Division, Madras.

Symposum on silting of reservoirs with special reference to estimating the life of Reservoirs and Measures to arrest the rate of Sedimentation.

the survey party. The position of bench marks, cross sections had to be acquainted with.

3.2.2. *Field operation.*—As the silt survey is being conducted once in every 5 years permanent cross section lines are already fixed for this tank.

Levels across each fixed cross section are taken, as most parts of the tank was dry and where the water depth was between 1 to 3 metres a boat was used for sounding operations. For this tank 60 permanent stations had been fixed. The main bund of the tank itself was taken as baseline and cross section has been aligned with reference to that baseline.

3.2.3 *Office Work.*—From the levels taken, contour map has been prepared. The area between various contours have been found out and from these areas the present capacity has been computed. The contour plan thus prepared is compared with the previous silt survey work. The reduction of capacity during the known intervals, have been found out which is taken as silt accumulated in the tank for the period of known years.

4. *Collection of test soil samples*—4.1. *Collection of soil samples for determining particle size distribution in the bed of the tank.*—Soil samples are collected from the bed of the tank while doing the field work, so as to cover the entire area.

Pits are dug for 30 cm. depth and soils are collected and packed in small packets, serially numbered with all details such as location, depth, etc.

4.2. *Collection of soils for determining the bulk density.*—Standard soil sample tubes used for collecting undisturbed soil samples and are properly protected with Parafin wax to retain the moisture in the soil till it is tested. Sample tubes are properly numbered and further particulars such as location of the pit, depth at which it is taken, etc., are noted on the soil sample tube itself.

In this silt survey, 100 samples are collected and tested for bulk density.

4.3. *Classification of soils.*—The designation of soils by the name of their principal constituents is faciliated by the Traiangular soil classification chart developed by Public Road Administration of the U.S.A. Soil Mechanics and Engineering Practice by Karl Terzaghi and Ralph Block. As per this triangular soil classification, the soil in the bed of Perumal Tank, the average composition of which is of sand 29.50 per cent, silt 21.20 per cent and clay 49.30 per cent, falls within the region marked "Lean Clay" hence this can be classified under "Lean Clay".

4.4. *Soil Classification contour.*—After ascertaining the composition of the soil in the various locations contour lines depicting the various composition are drawn so as to get a fair idea of the nature of the soil in the various locations of the tank. It is seen that sand and silt are generally found in the central part of the tank and high percentage of sand (41 to 60 per cent) is generally found in edge of the tank.

4.5. *Volume weight relationship of silt.*—"Faris" recommends the dry weight of 1 cubic metre of silt as 1,443 kg. (90 lbs. per cft.) for deposits to prolonged explosures. 1,122 kg. (70 lbs. per cft.) for short exposures and 418 kg. (30 lbs. per cft.) for permanently submerged.

In this case the volume has been tabulated as,

$$\text{Wet density} = \text{Dry density} \left\{ 1 + \frac{\text{percentage of moisture content}}{100} \right.$$

(*a*) *Samples subjected to prolonged exposures.*—This works out to 1.517 gm/cc.

(*b*) *Samples subjected to partial exposures.*—This works out to 1.579 gm/cc.

(*c*) *Samples subjected to submersions.*—This works out to 1.384 gm/cc.

On comparison of the volume of dry weight of soil samples subjected to the three types of exposures with the standards prescribed by Faris, it is observed that volumes in the first 2 cases are fairly agreeable and the last volume is almost double of the standard weight. In this survey, there is no sample under permanent submersion since no part of the tank bed is under this condition.

4.6. *Wet density and voids ratio.*—On the study of the results of the analysis of soils sample it is inferred that wet density and dry density decrease as the voids ratio and total percentage of fines increases.

5. *Life of the tank.*—This can be derived from the following methods:—

1. Life from average silt method.
2. Life from exponential equation.

5.1. *Average silt method.*—By calculating the average rate of silting for the known period, the years taken for silting 50 per cent capacity of tank can be found out and this will be the life of the tank.

In Perumal tank, the rate of silting for the first silt survey has been found out to be 11.667 hectare metre (94.81 acre foot) per annum and from the second silt survey it is 12.00 hectare metre (97.32 acre foot) per annum.

The rate of silting of Perumal Tank since 1961 is tabulated in the statement below:—

Period.	Number of years.	Silt in Mms.	Silt deposit (in Hectare) Metre. During the total period.	Per Annum.	Cumulative total.	Per 100 sq.km. of catchment area.	Average rate of silting.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1961-67	6	0.70	(−) 70	11.667	11.667	2.11	0.117 Mcm/annum.
1967-75	8	0.96	96	12,000	23.667	2.11	0.120 Mcm/Annum.

Hence life of the reservoir in year $= \dfrac{\text{Capacity in 1975}}{\text{Rate of silting for the period 1967-75 (latest is taken)}}$

$= \dfrac{12{\cdot}29}{0{\cdot}12} = 102{\cdot}40$ or say 102 years.

for 50% of silting will be 102/2 = 51 years.

(ie) life will be 1975 + 51 = 2026 AD

Calculation of capacity of the tank using

1. Prismoidel formula :

$$V : \frac{L}{3} \left(\sqrt{A_l A_u} + A_u + A_l \right)$$

Where V : Capacity between rwo contours in cum.

L : Contour interval in between

A_l : Area of the lower contour in sq. m.

A_u Area of the Upper Contour in sq. m.

2. Method of average contour area and multiplied with contour intervals.

For the Perumal Tank, the capacity of the tank works out to 12.13 M.cum. as per Prismoidel Formula and 12.29 M. cum. as per latter method. The difference is only 0.16 M.cum which is very little. For calculating the life of the tank as per average silt method capacity obtained as per average contour area (i.e.) 12.29 M.cum. is being adopted.

5.8. *Life of the tank by Exponential equation :*

(ie) $Y : A(e^{mx} .. 1)$

Where y : intensity of silt at Metre depth (i.e., metre below F.R.L.)

x : depth below F.R.L. in metre

e: Naperian base of logritham

A and m are constants.

It is required to evaluate A and m the constant for the given value of x and y. In the equation 'm' will be very small and hence expanding mx. in terms of powers x and y neglecting powers of my we have

$$y = A\left(1 + \frac{mx}{1} + \frac{m^2 x^2}{L2} + \ldots\ldots\ldots\right) \quad (1)$$

$$= Amx + \frac{Am^2x^2}{2}$$

Putting $K : Am$ and $L : \dfrac{Am^2}{2}$

$$Y = KX + LX^2$$

Fitting a curve to these points by the method of least squares.

$$Y_1 = KX_1 + LX_1^2$$

$$(y_1 - kx_1 - Lx_1^2)^2 \text{ must be minimum}$$

differentiating with respect to K and L

$$\text{i.e. } K \Sigma x_1^2 + L \Sigma x_1^3 = \Sigma x_1 y_1 \ldots\ldots\ldots (1)$$

$$K \Sigma x_1^3 + L \Sigma x_1^4 = \Sigma x_1^2 y_1 \ldots\ldots (2)$$

In the above equation X the depth below F.R.L shall conveniently be taken for different contours with F.R.L. as datum.

The cumulative intensity of silt Y upto a particular contour for the above equation shall be obtained by taking the average of the silt depth for all the cross section. The depth of silt being measured with respect to original bed level.

Solving the above equation we get L: (—) 0.075 and K: 0.3772 and further substituting the value of L and K we get.

A : (—) 0.9486

and m : (—) 0.3976

Now taking the equation of the curve

$$Y = A(e^{mx} - 1)$$

deducting annual curve 14 years (i.e.) from 1961 to 1975 and intensity of silt in "t" years may be represented as

$$Y = \frac{A}{14} t(e^{mx} - 1)$$

Integrating with respect to Y from x : O to L

Where x : depth below F.T.L.

L: Maximum depth below F.T.L. (5.14—21.12: 3.02 m.)

$$Y : \frac{A}{14} t \left(\frac{e^{mu}}{m} - x \right)_0^2$$

For 50% of silting of total capacity of 13·9519 MCM

$$\frac{13{\cdot}9519}{2} = (-)\frac{0{\cdot}9586}{14} t \left(\frac{e^{mu}}{m} - x \right)_0^{3{\cdot}02}$$

t = 81·65 or say 82 years.

Hence life of the tank: 1975 + 82 : 2075 **AD.**

In the method of average silting, it is assumed that the present rate of silting will remain uniform througout the life of the tank whch is not generally the case. The silting rate decreases with time especially when regime conditions are approached. The silting rate will considerably decrease after the deep portion and dead storage are filled up with silt. Hence the average silt method is not accurate and dependable. The phenomina is taken into account in the case of exponential equation and hence this result is more dependable.

Year	Annual storage loss.	Storage loss % of present capacity.	Capacity per sq. km. of drainage area.	Average annual sedimentation per sq.km. of drainage area.
(1)	(2)	(3)	(4)	(5)
196	0.117 Mcm.	0.839%	0.023703 Mcm/sq. km.	0.000209 Mcm/sq. km. of drainage area.
1975	0.120 Mcm.	0.905%	0.021985 Mcm/sq. km.	0.000214 Mcm/sq. km. of drainage area.

6. *Study of silt data.*—

6-1. *Silt depth contour.*—The deposits of silts at various places along the cross section in the bed of tank were noted over the original cross section and difference in silt level are noted. Comparing with this silt depth contour of 1975, the similar silt depth contour of the previous silt survey of 1967, the general study of the movement of silt delta has been made.

6-2. *Movement of silt delta.*—The Perumal Tank has been divided into 3 parts for the sake of convenience of study the silt delta.

6-2-1. *Reach I between C.S. 81 and 49.*—This reach includes the feeding source and all the surplus courses of the tank. During the first round of silt survey (i.e.) during silt survey done in 1967 this reach was badly silted but during the silt survey (i.e.) in 1975 it is observed that the deposit of silt is more in second reach than in this reach. This is mainly due to breaching of tank during 1972 floods.

6-2-2. *Reach II between cross section 49 to 20.*—This reach has been appreciably silted to a depth of 0.20 to 1.20 m. This shows that silt deposit has been moved from the reach I to reach II during years between 1967 and 1975.

6-2-3. *Reach III between cross section 20 to 1.*—In this reach also heavy silting was noted in the first round and during the subsequent surveys there is no such silting and on other hand there is scour also which is mainly due to breathing of the bund during the 1972 floods.

7. *Measures to combat silting up of tank.*—7.1. *Source of sediment.*—There are seven principle source of stream borne sediment, viz.—

1. Sheet erosion by surface run off from precipitation on agricultural, range forest and waste land.

2. Gullying or the cutting of channels in soil or the consolidated geologic formation by concentrated runoff.

3. Stream channel erosion including bank cutting and bed degradation of formerly well defined channels.

4. Mass movements of soils—land slides, slumps and soil creep.

5. Flood erosion of removal of surface soil by flood water during rainy season.

6. Erosion incident to cultural development including road, rail roads, power lines and clearing for houses and industrial projects.

7. Mixing industrial and sewage waste discharged into streams left in waste dump favourable to erosion.

Of this 1st condition is more important for this tank because a major portion land adjacent to the foreshore edge of the tank are cultivated with the help of pump set. During heavy rains all the loose earth in these ploughed lands got eroded and conveyed to the tank. For this tank there are 2 courses of stream which lead the flood water in the foreshore side. One of these streams is called "Kannadi Odai" and the other "Thambi Pettai Voikkal". The latter carries heavy silt to the tank during rainy season.

The 2nd, 3rd and 4th condition are by far the most important quantitatively in all large drainage areas although for small local areas other sources may be of major importance. The last condition does not exist in case of Perumal Tank.

7.2. *Measure to combat silting of tank.*—Sediment control requires two basis approaches. 1. Handling of sediment where it creates a problem; and 2. Reduction of the rate of sediment production from the drainage area.

7.2.1. Control of erosion or sediment production on the water shed is the soundest approach to reduce the rate of silting, since it strikes at the basic cause itself. Application of erosion control measures on large water sheds however is relatively long term undertaking which has to be studied in detail on individual merits.

7.2.2. *Reduction of the rate of sediment.*—This can be spilt up into 3 parts. They are—

1. Vegetative screens in water shed.

2. Water shed structures; and

3. Water shed land treatment measures

7.2.2.1. *Vegetative screens in water shed.*—Vegetative screens consist of lense plant growth through which sediment laden water must diffuse and flow with reduced velocity that causes decomposition. This requires considerable areas of waste, plain land. Where the total water-supply is seriously difficient they may be objectionable because of large quantity of water consumed by evopo-transpiration. Further in humid regions they may produce swampy land that creates health hazards.

This method of prevention is worth attempting in the Perumal Tank area since this tank has a free catchment area of 191 sq. km. but it has to be taken up with the private land owners in these areas.

7.2.2.2. *Water Shed Structures.*—These include such structures at sedimentation basin to trap sediment below eroding areas and erosion control structures to half the production of sediment.

For the Perumal Tank a cross bund across the tank along the cross section near the in fall of "Thambi Pettai Voikkal" may be trained so that the silt deposition beyond this region can be considerably reduced.

Since the unit cost of storage is a specific area which normally decline as the size of the tank or reservoir increases, it is generally more economical to incorporate additional capacity in the tank itself for sediment accumulation than to develop a separate structure upstream, specifically for the purpose of storing sediment. In Perumal Tank it is not feasible because for want of space needed for sediment storage. Hence the question of providing sedimentation basin to store sediment permanently for the life of tank or to store sediment for the periodic clear out has to be investigated in detail. This facilitates reduction of coarse grained

sediment only. Across main drainage infalls into Perumal Tank structures such as drop inlets and chutes for reduction of gully erosion, stream bank revetment to reduce the stream bank erosion and sills or drop structures for stream bed stabilisation can be considered. The question of providing by-pass canals to divert sediment laden flows around the tank also requires to be investigated. To avoid the rain water flowing from the foreshore agriculture land to the tank necessary bund can be constructed and to allow the rain water only through the channel which can be suitably lined so that erosion of side and bed of the channel can be avoided.

7.2.2.3. *Water shed land measures.*—If the primary source of sedimentation in shed erosion, land treatment measures provide an effective and economical means of reducing erosion and sediment. These measures include soil improvement proper tillage methods, strip cropping, terracing crop relation, etc. The improvement of soil by the addition of organic residues increases the infiltration rate and reduces the sheet runoff and sheet erosion. The infiltration rate may also be increased by tillage methods such as "basin listing" and "Contour ploughing". The installation of terrace not only promotes infiltration but also reduces the effective length of slope with corresponding reduction of erosion velocities.

Of all the conservation measures influencing sheet erosion, the most effective and the easiest to manipulate is the "cover". The conversion of land use from up and down intertilled crops and follow to small grains, meadow and other uses with protective cover results in substantial reduction of the rate of sheet erosion.

7.3. *Removal of sediment*—7.3.1. *Venting sediment.*—Overflow spillway which encourage the discharge of surface water from a reservoir may actually skin off clear water and retain the mere turbid water from which the sediment eventually becomes deposited. Occasionally appreciable amounts of sediment may be vented from reservoirs by use of gated outlets or special curtains, to encourage movement of high concentration of sediment in suspension through or over the dam. Under certain conditions sediment moves through reservoir in well defined stratified flow.

The effectiveness of venting methods depends upon maintaining the movement of sediment while still in suspension. Deposition of sediment reduces the bottom slope and the cohesive and adhesive forces on particles in deposited sediment are greater than the tractive force of flow normally developed by release of water through gated outlets. As a result erosion and entrainment of deposited sediment particle are minor with the exception of a very localised area adjacent to the intake.

7.3.2. *Removal.*—Deposited sediment may be removed from the bed periodically by hydraulic or mechanical means. Generally this is the only method that can be used successfully to restore the capacity of small reservoir and tanks. If the above method is not economical the possibilities of increasing the capacity of the tank by raising the F.T.L. may be thought of.

8. *Conclusion.*—During this round of silt survey it has been calculated that storage loss for eight years (1967 to 1975) was 0.12 McM and during last survey for 14 years it was 0.119 McM. There is no much difference between these two readings.

At the present rate of loss of capacity it has been estimated by the exponential equation method that the tank will get silted upto 50 per cent of its capacity by the year 2057 AD.

As already mentioned in this respect, the large scale erosion, at flood times, in the cultivated lands in the catchment area at the foreshore side of the tank account for the high rate of silting. However all the deep portions in the bed of tank has almost been filled up and the rate of silting is likely to decrease hereafter since the entire silt carried by the inflow may not get deposited and major portions of the silt may get washed away by the outflow. This has to be watched and analysed in the future survey only.

References.—

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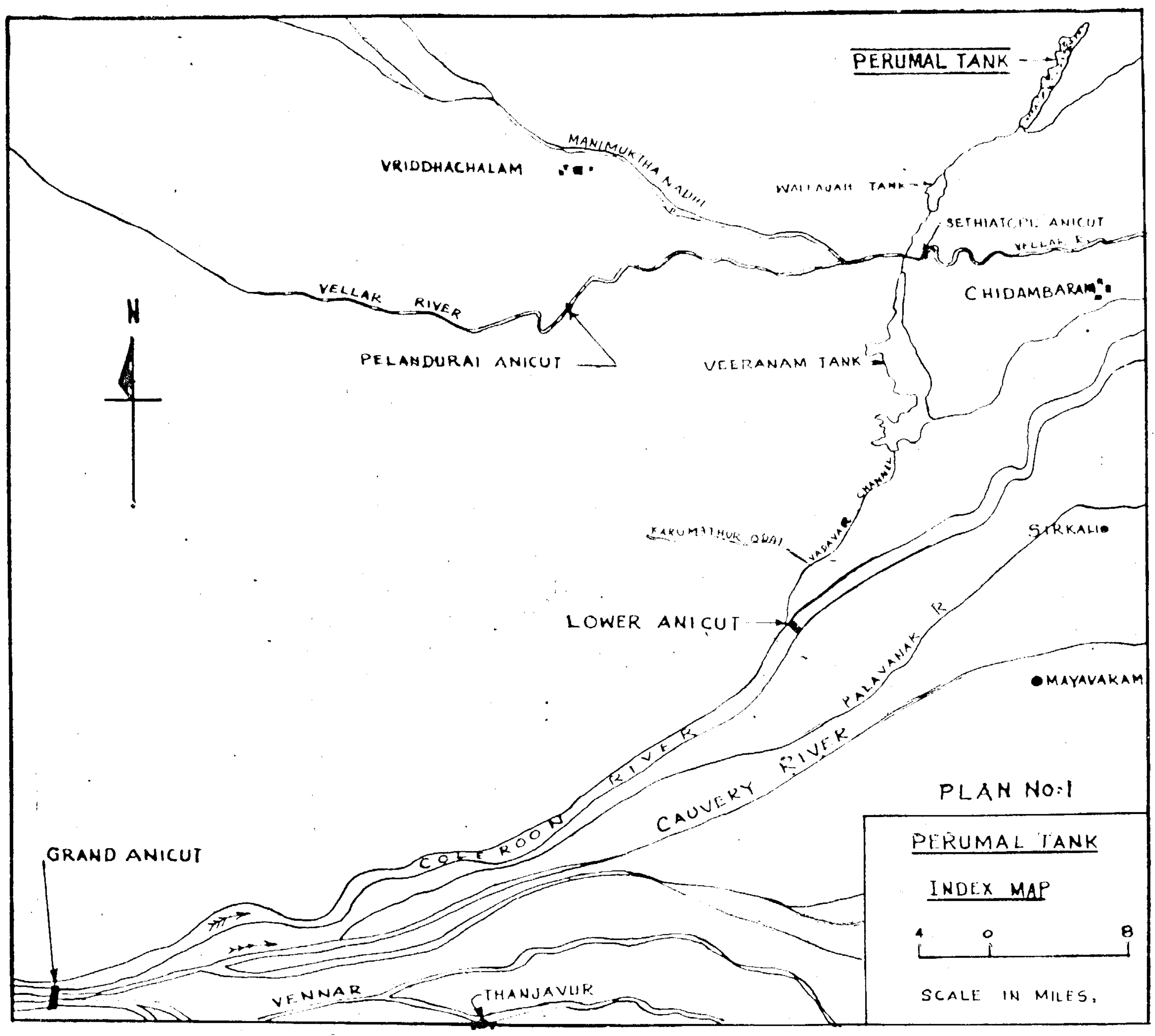
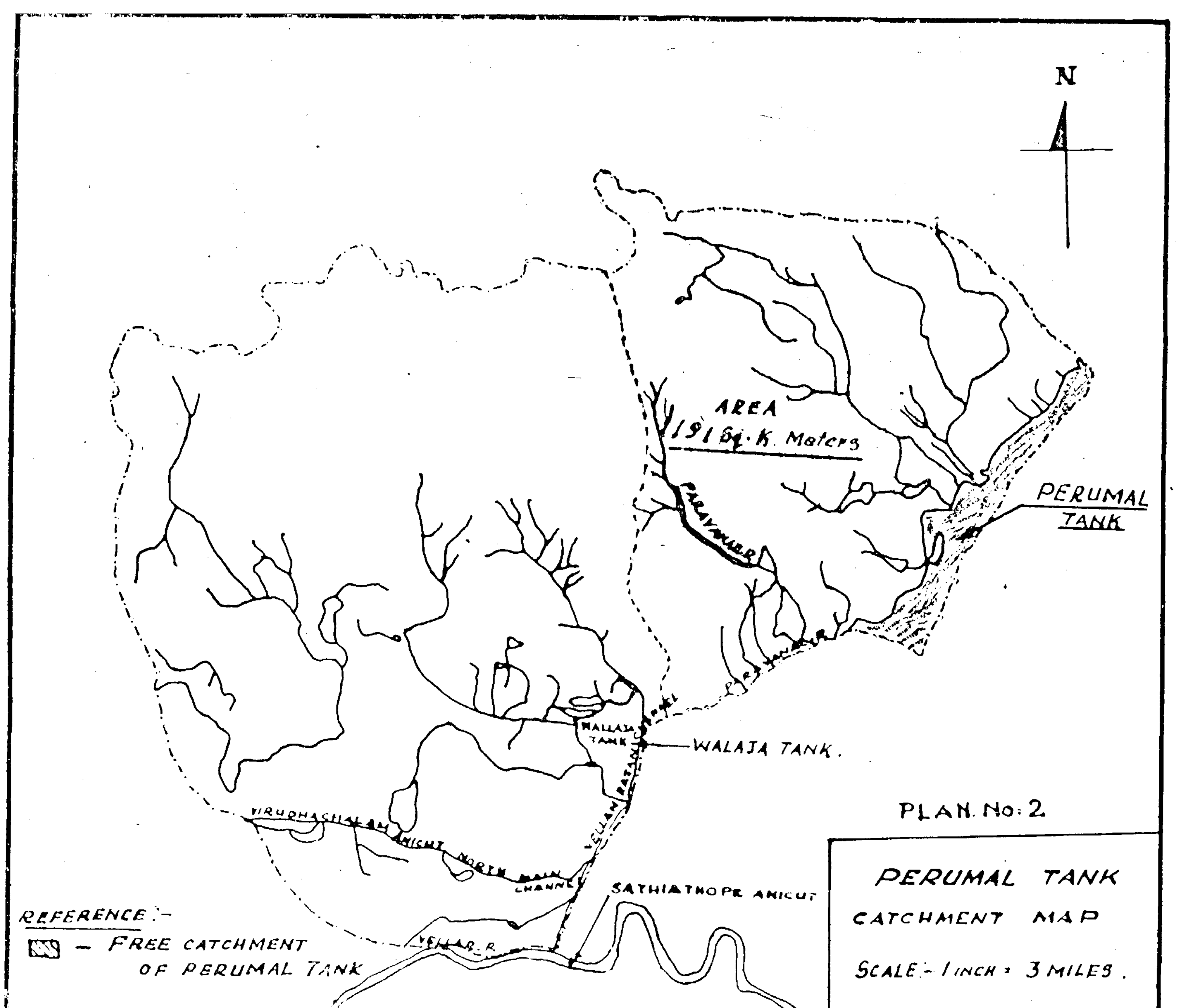
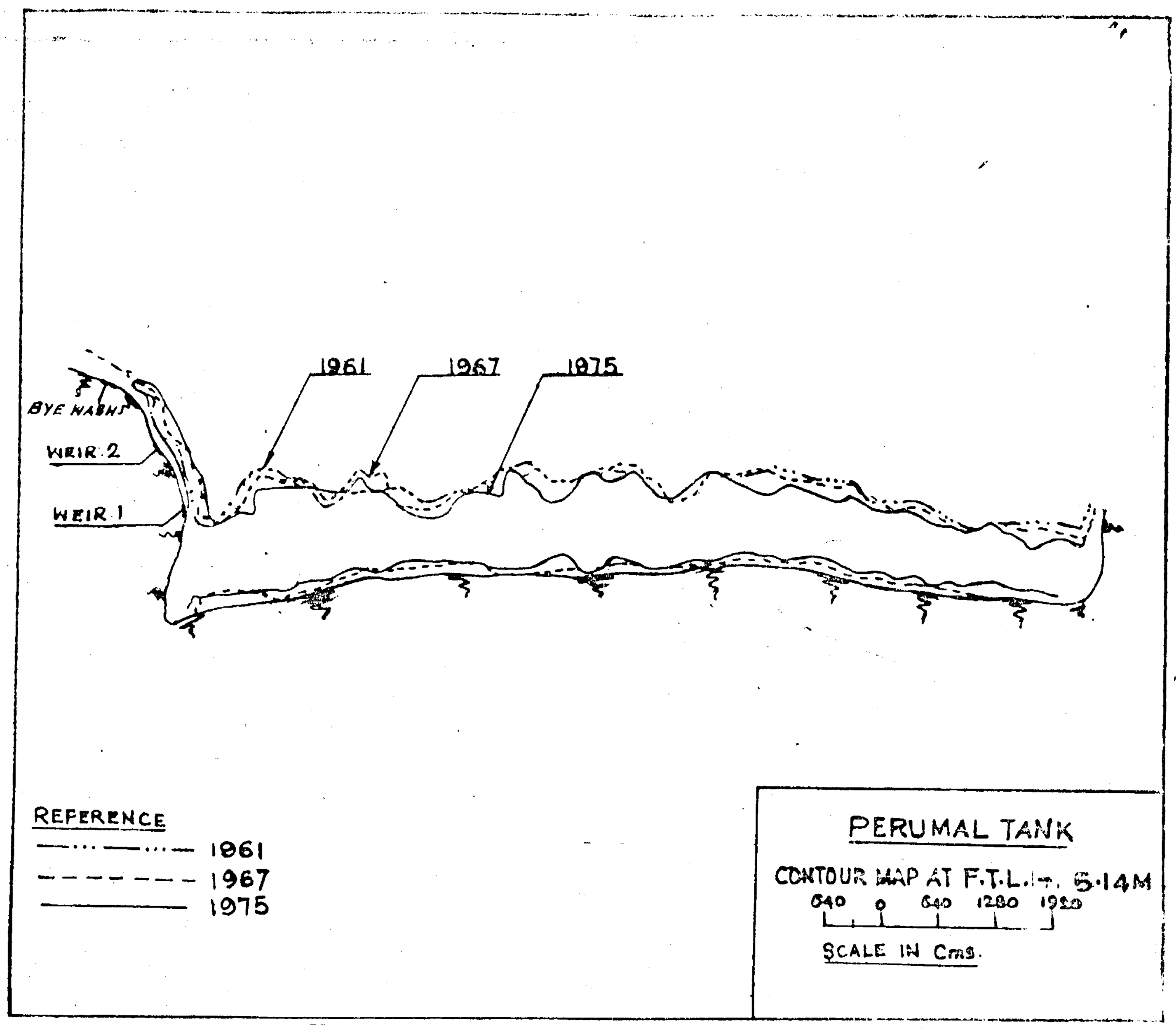
2. New Irrigation Era Volume XII, Issue 1 published by the Irrigation Department of Tamil Nadu Government.

3. New Irrigation Era Volume XII, Issue 4 published by the Irrigation Department of Tamil Nadu Government.

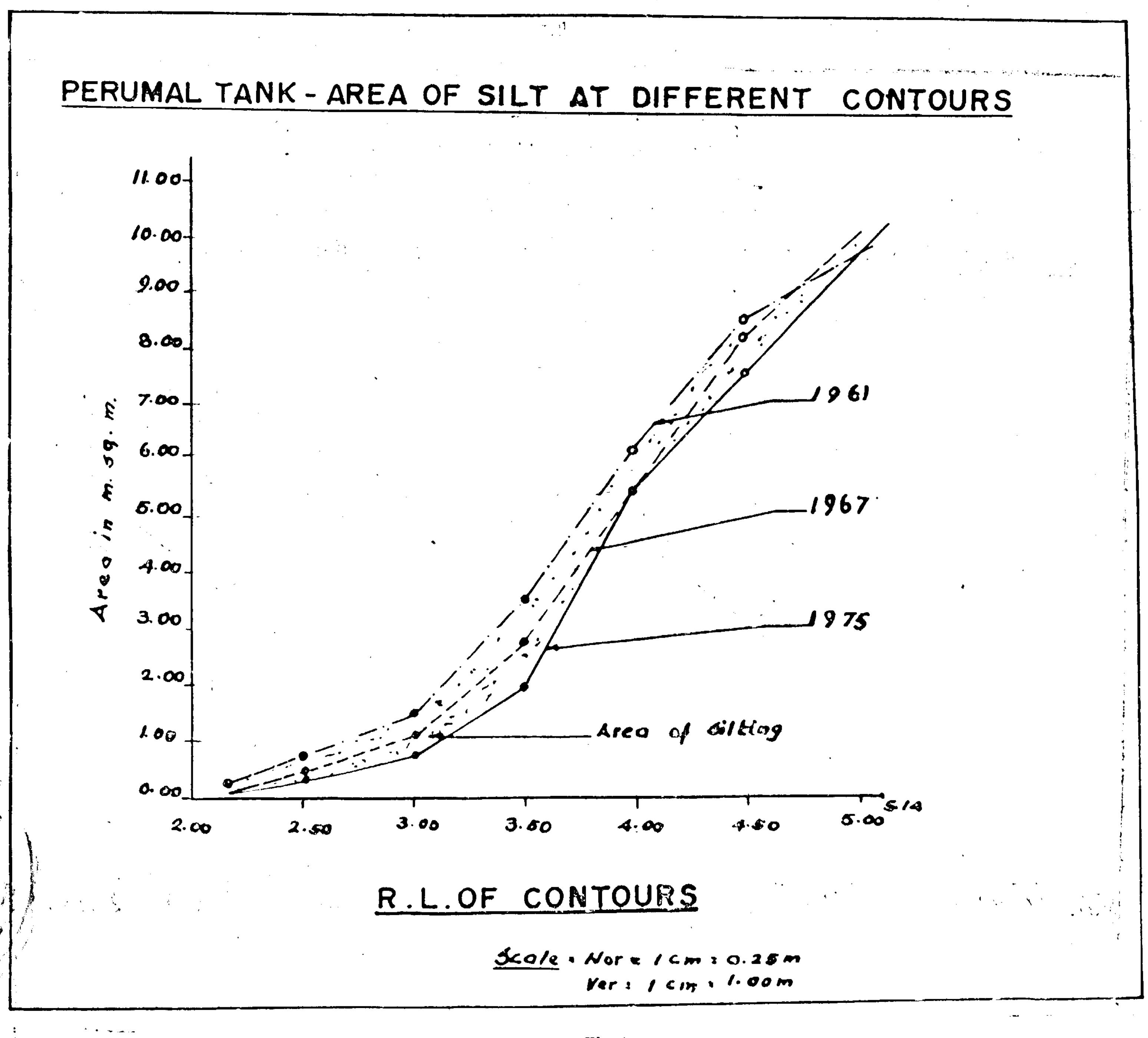

PERUMAL TANK
VRIDDHACHALAM
MANIMUKTHA NADHI
WALLAJAH TANK
SETHIATOPE ANICUT
CHIDAMBARAM
VELLAR RIVER
PELANDURAI ANICUT
VEERANAM TANK
N
SIRKALI
LOWER ANICUT
MAYAVAKAM
PALAVANAR R.
COLEROON RIVER
CAUVERY RIVER
GRAND ANICUT
VENNAR
THANJAVUR
PLAN No:1
PERUMAL TANK
INDEX MAP
4 0 8
SCALE IN MILES.


N
AREA
191 Sq. K. Meters
PARAVANAR
PERUMAL TANK
WALLAJA TANK
WALAJA TANK.
PLAN. No: 2
VIRUDHACHALAM
NORTH MAIN CHANNEL
SATHIATHOPE ANICUT
VELLAR R.
REFERENCE:-
– FREE CATCHMENT OF PERUMAL TANK
PERUMAL TANK
CATCHMENT MAP
SCALE:- 1 INCH = 3 MILES.



BYE WASH
WEIR 2
WEIR 1
1961
1967
1975
REFERENCE
1961
1967
1975
PERUMAL TANK
CONTOUR MAP AT F.T.L. 5.14M
640 0 640 1280 1920
SCALE IN Cms.

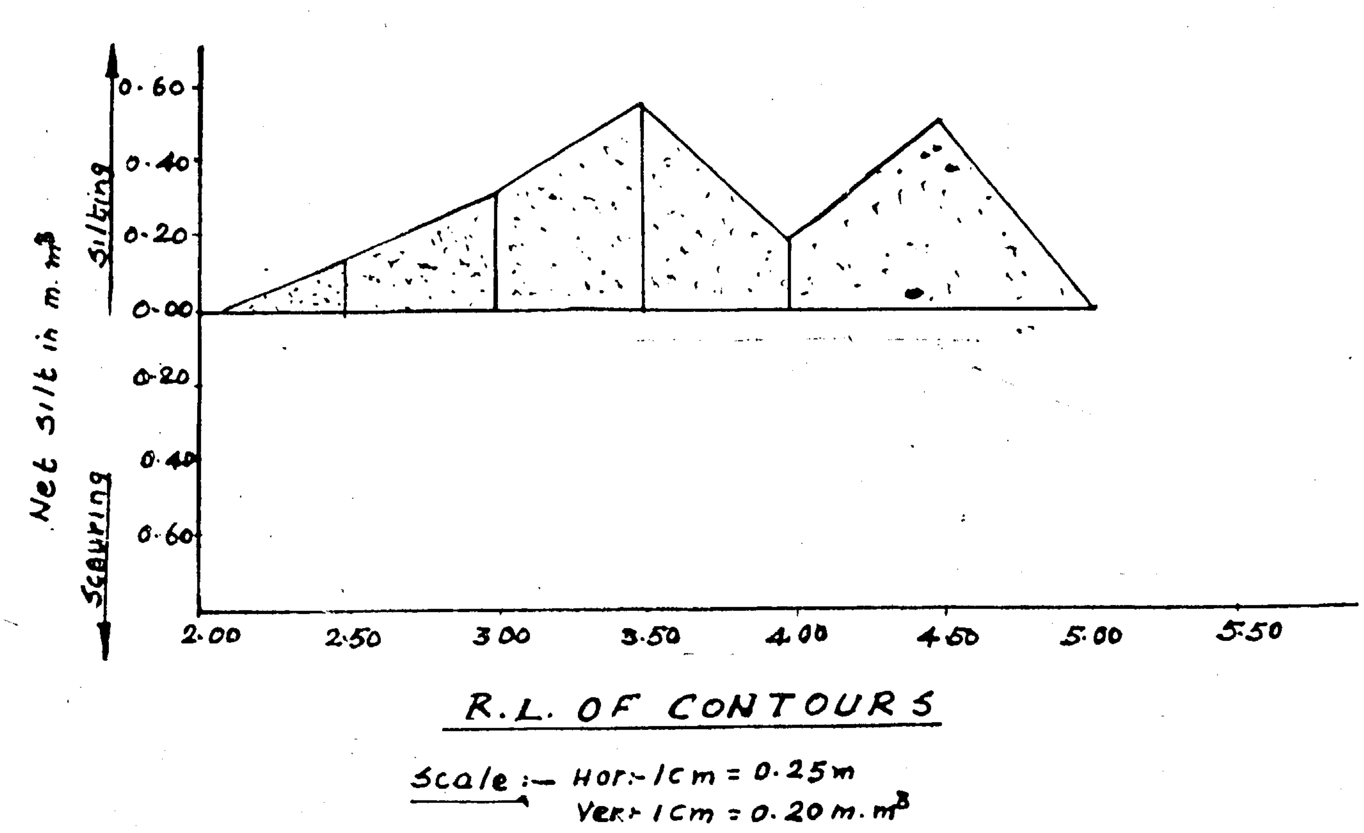
Fig 3



PERUMAL TANK - AREA OF SILT AT DIFFERENT CONTOURS
Area in m. sq. m.
11.00
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.14
1961
1967
1975
Area of silting
R.L. OF CONTOURS
Scale : Hor = 1 cm : 0.25 m
Ver : 1 cm : 1.00 m

Fig 4

PERUMAL TANK- VOLUME OF SILT AT DIFFERENT CONTOURS



QUANTITY OF SILT DEPOSITED IN PERUMAL TANK

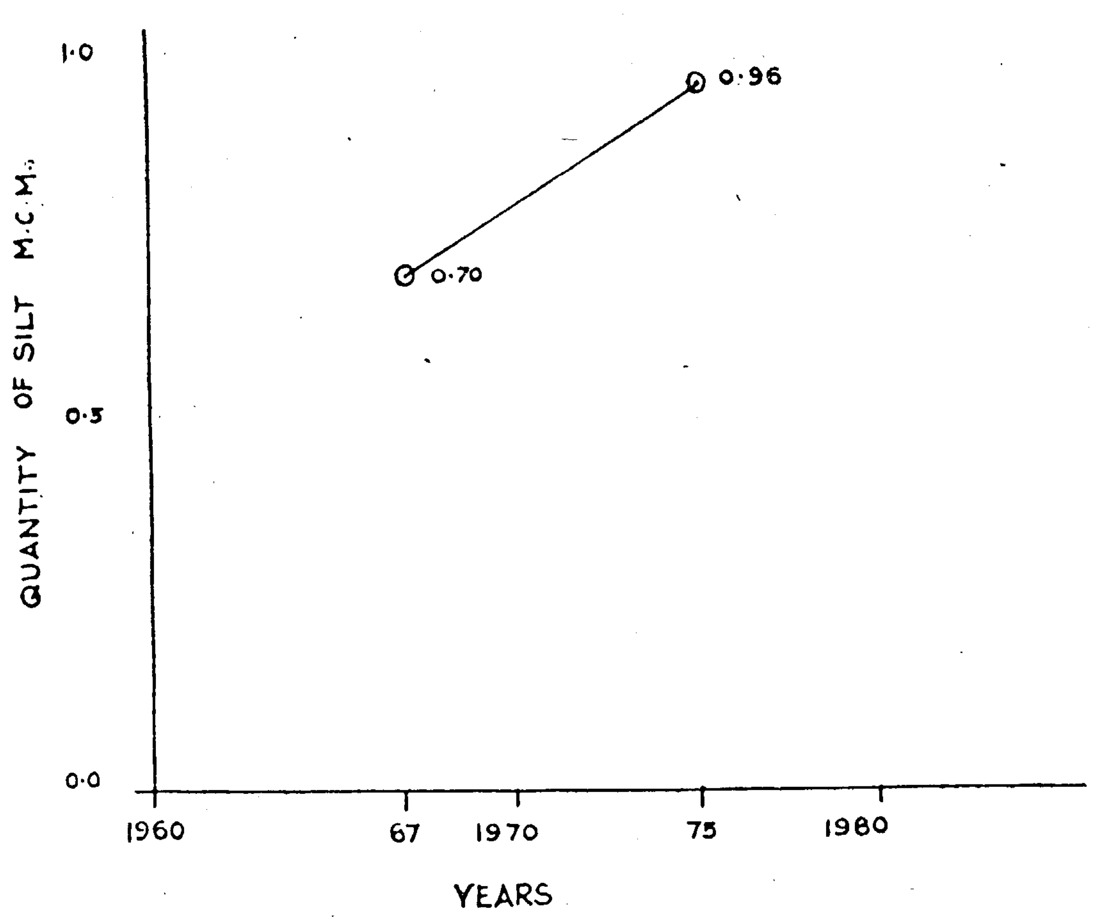


Fig 6

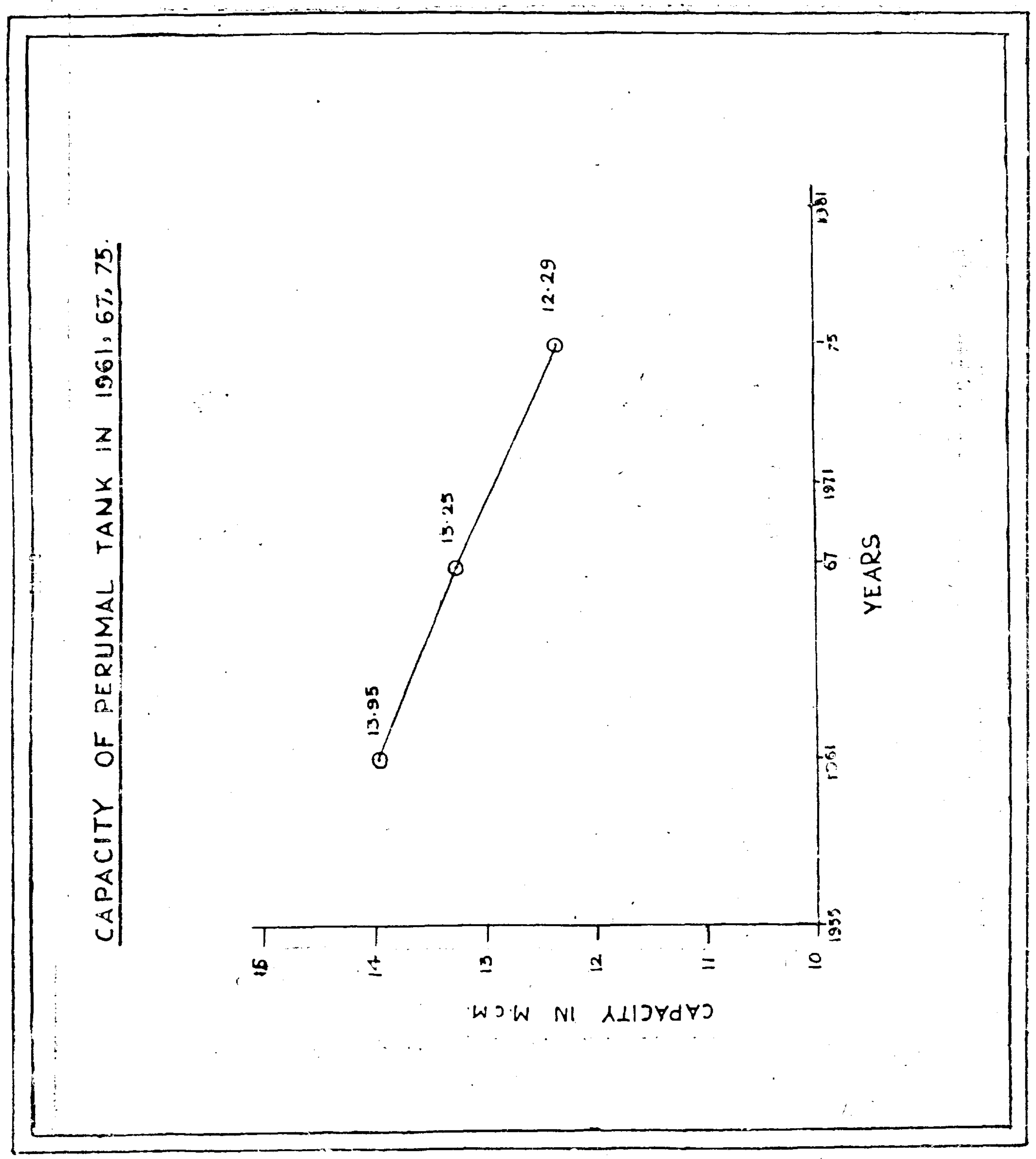


Fig 7

ZONING OF MASONRY IN SHOLAYAR DAM IN TAMIL NADU.

Sholayar dam, constructed across Sholayar in Anamalai hills is an important link in Parambikulam-Aliyar project. This is one of the eight dams under Parambikulam-Aliyar Project, constructed for diverting some of the west flowing streams into the semi-arid eastern slopes and plains. The water from Sholayar dam are diverted to the adjacent Parambikulam reservoir through a tunnel. The total length of dam is 1182 m (3882') of which the length of the measonry dam is 346 m. (1132') and that of earth dam is 836 m (2750'). The dam, which is the second highest masonry dam, rises to a height of 105 m (345') at the deepest foundation level. The capacity of the reservoir formed is 157 million m (5540 mcft.). A noteworthy feature of this dam is the use of rubble masonry with suitable mortar even in the heavily stressed portion of the dam, instead of cement concrete.

The general practice of mortar proportioning for low dams is as follows:

(i) First five courses of the dam are built in C.M. 1 :2¾ for the full width.

(ii) Above this the front 2.75 m. (9.0') alone is built in C.M. 1: 2¾.

(iii) The rear of the spillway is usually built with C.M. 1:4.

(iv) For non-spillway C.M. 1:5 is used for the top 50' and C.M. 1 : 4 below.

The procedure of adopting a suitable mix for mortar in a particular portion of a dam taking into account the resulting stresses is called zoning of masonry. The zoning of masonry is done to achieve economy and to utilize the strength of cement and other materials to its full advantage ensuring at the same time the safety for the masonry. Zoning of masonry has been done for Sholayar dam, in view of its unprecedented height.

The maximum section of the dam is analysed for principal stresses. These stresses are determined at the nodal points of a grid formed by horizontal lines spaced at 40' intervals and vertical lines spaced at 20' intervals for three different conditions of loading, viz.--

(i) Reservoir empty;

(ii) Reservoir full without uplift pressure; and

(iii) Reservoir full with uplift pressure.

For determining the principal stresses at each point, the normal stress on horizontal plane (*oz*) the shear stress (Tzy.) and normal stress on vertical plane (*oy*) are calculated. The maximum stress occuring under any of the three loading conditions is chosen for each nodal point and stress contours drawn by the method of interpolation in the section of the dam and the different zones demarcated. The range of stress selected for each zone depends upon the mortar strength and factor of safety.

Generally, in order to test the strength of masonry it is considered enough if a mortar cube of suitable size used for the construction is tested. The Executive Engineer, Soil Mechanics and Research division, Madras, conducted tests on 4" cubes and 6" cubes, with 15 per cent replacement of cement by flyash, using sand obtained from Palar river The 90 days strength of mortar of different mixes (both for 4" and 6" cubes) are found to be as follows:--

Mix.	4" cubes strength T/sq.ft.	6" cube strength. T/sq.ft.
1 : 2¾	262	212
1 : 4	138	122
1 : 5	72.85	72.26

The zoning of masonry in Sholayar Dam was based on the results for 6" cube. A factor of safety of 10 was generally adopted. The stresses varied from 4T sq.ft. to 25.75 T sq.ft. The maximum stress of 25.75 T sq.ft. was found to occur at the toe of the dam at Eln. 2960.0 for reservoir full with uplift. Though the maximum allowable stress in masonry with C.M. 1: 2¾, with a factor of safety of 10 has been determined to be only 21.2 T sq.ft. this mix has been used for zones with stress ranging from 21.2 T sq.ft. to 25.75 T sq.ft. also by encroaching into the factor of safety as only a factor of safety of 8 has been considered in the case of Nagarjunasagar Dam.

Based on above points the section was divided into four zones.

(i) Zone A : Mix. 1:2¾

(ii) Zone B : Mix. 1 : 4

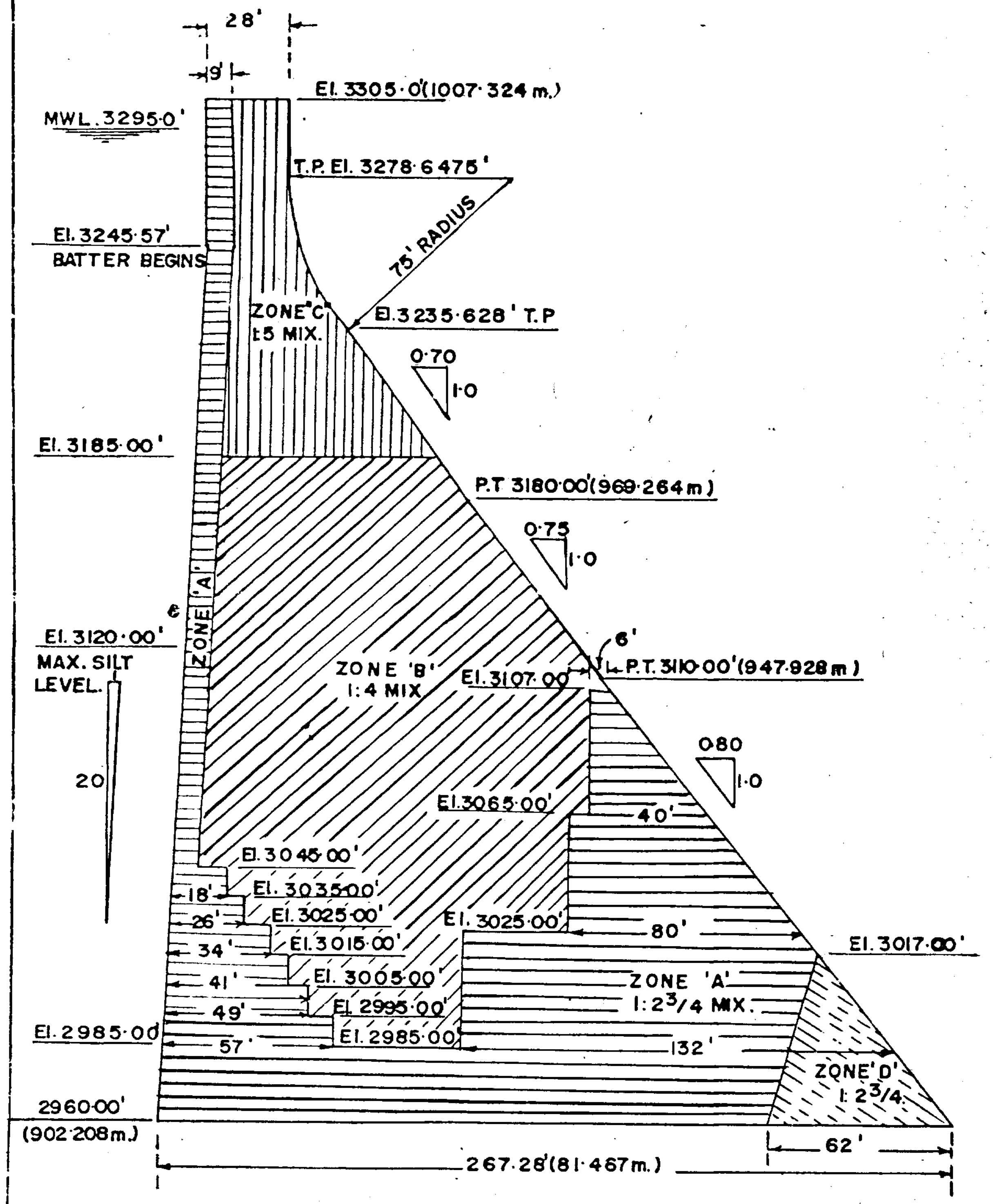
(iii) Zone C : Mix. 1 : 5

(iv) Zone D : Mix. 1 :2¾ (where the stress exceeds 21.2 T/sq.ft.

A sketch showing the various Zones is furnished:

Zoning of masonry is one of the Scientific ways of approach for the construction of high masonry dams, which has been successfully adopted in Sholayar dam, which is one of the highest masonry dams in the world. This method can further be developed by studying the optimisation of number of zones to be provided in a section, the reduction in the factor of safety and determining in laboratory the ultimate stress in composite masonry instead of cement mortar.

Presented by the Designs Circle, P.W.D. Tamil Nadu



ZONING OF MASONRY IN NON OVERFLOW SECTION

OF

SHOLAYAR DAM

Trd: N.S.K.

ECONOMIC DESIGN ASPECTS OF EARTH DAMS OF MEDIUM RIVER VALLEY PROJECTS IN TAMIL NADU.

Earth dams are invariably resorted to for forming small and medium sized reservoirs because of the availability of suitable soils and foundation conditions. From a study of the performance of some of such existing dams, it is seen that there is scope for economising on the design based on the advancement of soil sciences and construction techniques. The various components in which such economy can be effected are discussed below:

1 *Cut off trench:*

The side slopes now adopted are uniformly 1:1 irrespective of the type of soil met with.

As the cut off trench is normally backfilled with impervious soil as quickly as possible after excavation, a steeper slope of 1½ : 1 is possible in most of the soils. Only where the foundation soil is loose side slopes of 1 : 1 can be adopted.

2. *Filters:*

Hitherto the practice was to provide filters of 0.9m. thickness for dam heights upto 9m. and of 1.65m. thickness for greater heights even though the thickness worked out to much less from theoretical considerations.

As per the revised proposal a filter of thickness 0.9 m. will be provided for dams upto 15m. height and of thickness 1.2m. for greater heights. This revision will result in savings in sand and broken stone which will be generally substantial in case where the quarry site for broken stone is located at considerable distances from the site of earth dam.

3. *Revetment:*

The standards followed for the hand packed revetment on the front face of the dam were 45cm. thickness over 30cm. gravel backing upto 9m. height and 60cm. thickness over 45cm. gravel backing for heights from 9m. to 21m. and 90cm. thickness over 45cm. gravel backing for heights greater than 21m. These standards are very conservative considering the low fetches of the medium and small sized reservoirs and also the fact that the revetment is well packed. Therefore, now it is proposed to provide 23cm. thick revetment over 23 cm. gravel backing for the lower half of the front face of the dam and 45 cm. thick revetment over 23cm. gravel backing for the top half of the front face. A berm of 2m. width will be provided where the change in the thickness is introduced and 45 cm. thick revetment will protect this berm. A larger thickness is proposed at the top half in order to resist the higher waves likely to result in the higher elevations of the reservoir due to longer fetch.

4. *Free Board:*

The wave height is calculated by using Molitor's formula and the free board required is computed after giving due allowances for other factors. This free board is allowed as it is (to the top of bund) without reckoning the height of the parapet. Generally a masonry parapet of 0.9m. is provided for the earth dam in front edge of the road. If atleast a part of this parapet can be included in the free board, then the crest of the dam can be lowered, thereby effecting savings in earth dam and masonry dam or weir.

Now, it is proposed to reckon 0.6m. height of the 0.9m. high parapet (to be built in cement mortar) in the free board which will result in lowering the T. B. L. by 0.6m. Provision of staggered horizontal wave suppressors at and around M. W. L. in about 3 rows will help to reduce the wave run up.

5. *Top Level of Hearting Zone:*

The top level of impervious zone is taken 0.6m. to 0.9m. above M.W.L. whereas it will suffice to have the impervious zone upto M. W. L. only. This proposed change will help to reduce the cost in cases where impervious soil has to be conveyed over long distances.

6. *Road Width:*

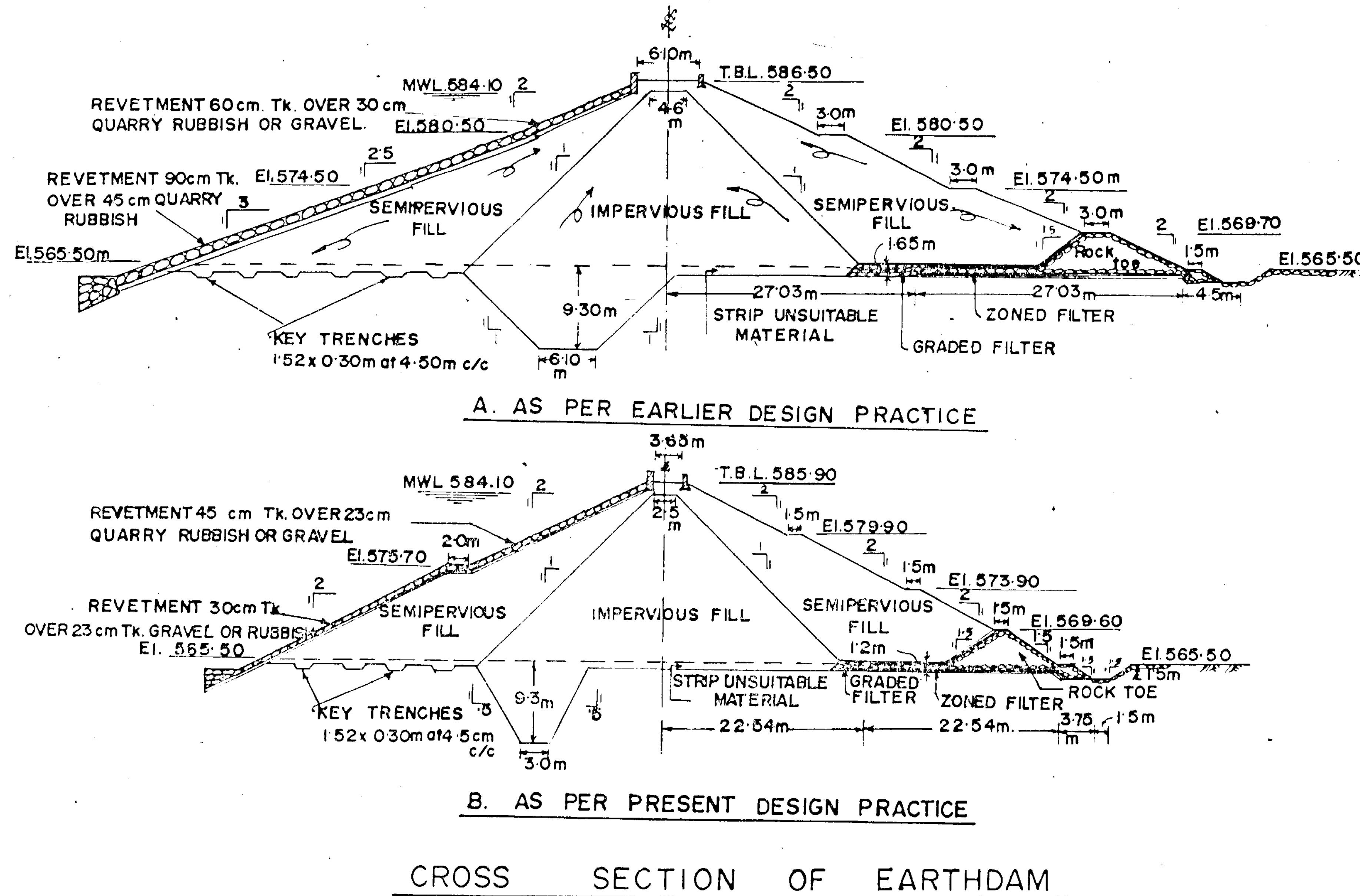
Considerable economy can be effected by reducing the road width to the optimum requirement. At times road widths of 6m. are adopted where such width is not required from considerations of traffic on the road over the dam. So it is proposed to adopt a road width of 3.65 m. in all cases where regular traffic is not expected on top of the dam, and when the stability analysis permits the reduced top width.

A case study of an earth dam of a proposed reservoir has revealed that an overall savings of 29 per cent in cost will be effected if the above modifications in design are adopted. Statement annexed shows the savings in individual items on the Earth dam taken up for case study.

Presented by the Designs Circle, P.W.D. Tamil Nadu

STATEMENT

Sl. No.	Description of the Component item in Earth dam.	Co per prv dpro procedure: Quantity M³	Rate per M³	Amount Rs.	Cost as per the revised design procedure: Quantity M³	Rate per M³	Amount Rs.	Savings	Savings in cost. percentage
1.	Cut off trench excavation	36000	2·45	88200	25000	2·45	61250	26950	30%
2.	Filling cut off trench with impervious soil	36000	9·27	333720	25000	9·27	231750	191970	31%
3.	Formation of impervious core	235578	9·27	2183808	158496	9·27	1469258	714550	26·7%
4.	Formation of casing section	300128	9·27	2782187	234314	9·27	2172091	610096	
5.	Gravel backing for Revetment	12593	13·23	166605	7585	13·23	100350	66255	39·7%
6.	Revetment	16000	39·56	632960	12000	39·56	474710	158243	25%
7.	Quarry rubbish for graded filter	6000	13.23	79380	4200	13·23	55566	23814	34·8%
8.	Metal for Zoned filter	4500	41·10	184950	3300	41·10	135630	49320	
9.	Coarse sand for zoned filter	5800	12·82	74356	3700	12·82	47434	26922	
10.	Fine sand for zoned filter	5900	14·00	82600	3200	14·00	44800	37800	
11.	Rock Toe	34205	13·23	452532	16277	13·23	215345	237887	52·4%
	Total			7061298			5008194	2053104	29%



CROSS SECTION OF EARTHDAM

Trd: N.S.K.

A SHORT NOTE ON THE PARTICIPATION OF P.W.D. IN ALL INDIA TOURIST TRADE FAIR 1977.

1. *Introduction.*—The Tourism Development Corporation, which is an undertaking of the Government of Tamil Nadu conducted the All India Tourist Trade Fair, 1977 during the period 2nd January 1977 to 6th March 1977 at Madras. The Fair was located near the Victory Memorial on both banks of the Cooum River, occupying a major portion of the Island Grounds, covering an area of 12.00 hectares. As it was expected that the Fair would attract visitors from all over India besides foreign tourists, the Department decided to participate in the Fair by putting up a pavilion.

2. The Public Works Department put up its pavilion of size 60'0" x 25'0" with an attractive frontage of a typical spillway of a measonry dam. Arrangement was made for the water to spill over the Spillway sections, as a natural dam. The entrance and exit were provided similar to the drainage gallery adits in the Dam. The interior of the Pavilion was decorated with false ceiling and sides with pleasing colours providing proper ventilation and lighting.

3. *Models Exhibited—(a) Running Models.*—(1) *Deluge in Madras.*—The running model illustrated the important anicuts and tanks in and around Madras City and means of controlling floods. The water sources of the City were clearly exhibited from Nagari Hills to Madras City. The drainage system to Chembarampakkam tank with surplus arrangement to Adayar River were also indicated with proper colour schemes.

(2) *Manniar Silt Ejector.*—Silting in Manniar branch of Cauvery River in Tanjore District was a major problem. After conducting detailed model studies and research, a silt ejector was suggested and constructed across Manniar. Now the problem has been solved. A typical running model of the Manniar Silt ejector was prepared by Institute of Hydraulics and Hydrology, Poondi has been exhibited. The working type model illustrated the removal of silt clearly.

B. *Irrigation Models.*—(1) *Chembarapakkam Tank.*—The Chembarampakkam Tank lies about 16 miles west of Madras with an ayacut of 13,223 acres. The surplus from this tank drains into Adayar River. This is the biggest tank in Chingleput district with a capacity of 0.95 Million cubic metre.

(2) *Standardisation of Tanks.*—The model was intended to exhibit the contrast between old and the modern tank irrigation systems.

(i) *Old Tank Irrigation System.*—Under this system irrigation is done with 'Etram', 'Kaval' and 'Sal'. The banks of the tanks, field bothies, etc., are not proper according to standards.

(ii) *New Tank Irrigation System.*—Under this system the banks have been formed to standards, field bothies modified and Irigation done with modern facilities.

(3) *Kodaganar Reservoir.*—This scheme has been proposed in Madurai district across Kodaganar River. The cost of the scheme is about Rs. 485 lakhs and the ayacut benefitted is 5,500 hectares.

(4) *Pambar Reservoir Scheme.*—This Scheme has been proposed in Uthangarai taluk in Dharmapuri District at a cost of about Rs. 177 lakhs. Area that will be benefitted by this scheme is 1,618 hectares

(C) *Building Models—*(1) *Madurai Corporation Buildings.*—This model shows the building constructed at Madurai to accommodate the Corporation office of Madurai City. The estimated cost of the buildings is about Rs. 71 lakhs.

(2) *Ezhilagam.*—This Buildings is being constructed adjoining the Main Ezhilagam Building to accommodate Government offices. The Estimate amount is about Rs. 18 lakhs.

(3) *New Secretariat Multi-storeyed Building.*—This ten storeyed building is being constructed to accommodate the offices of the Secretariat adjacent to the present buildings. The estimated cost is about Rs. 132 lakhs.

(4) *Labour Welfare Board Building.*—This multi-storeyed building with seven floors is being constructed at a cost of about Rs. 37.57 lakhs in Madras City.

(5) *Cancer Hospital Building.*—This Hospital Building is being constructed near Kancheepuram at an estimated cost of about Rs. 37 lakhs. It is designed to accommodate 100 beds.

(D) *Scientific Models.*—(1) Rocking Cradle for crying Baby.

(2) Different colours in rotating disc.

(3) Alibaba's Cave.

(4) Flame in the Fish Tank.

(5) Optical Illusion Model.

(E) *Research Models.*—

(1) Solar Water Heater. It is a working model to heat water using Solar energy and store it in a tank.

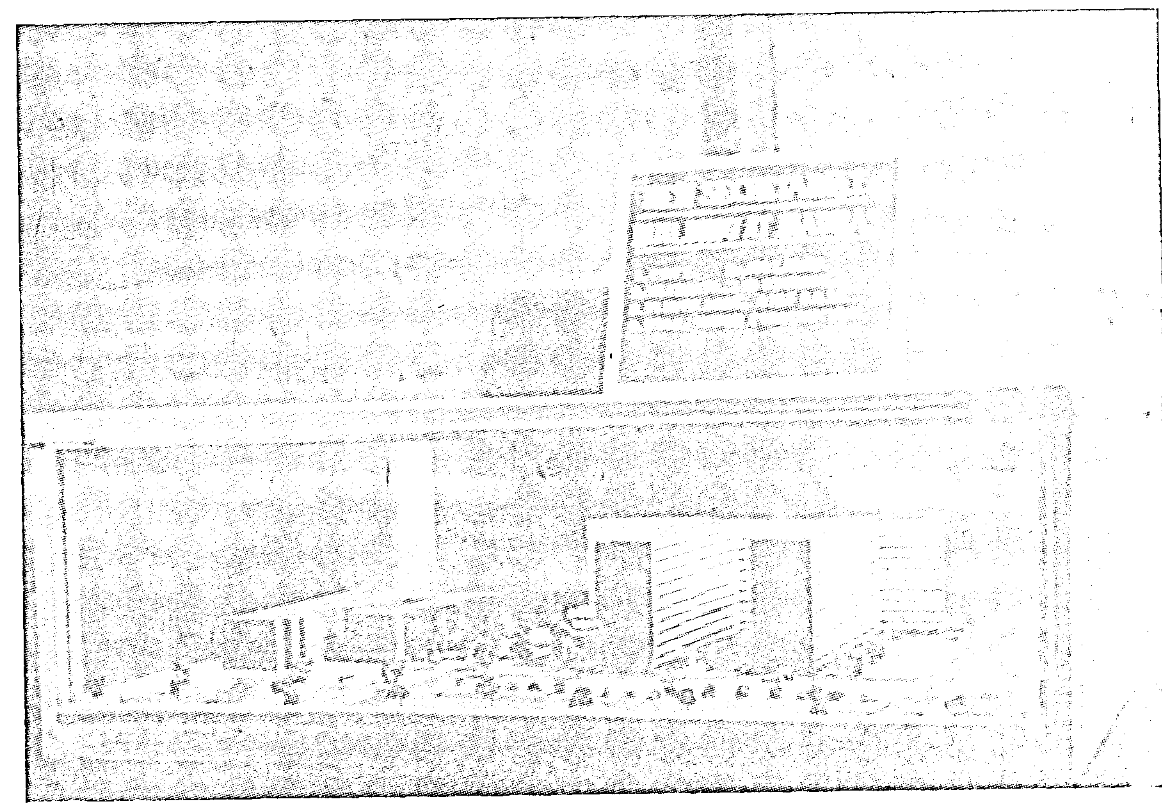
(2) Wind Mill: To pump water using wind power.

(F) *Public Interest.*—A beautiful park was created just in front of the Pavilion, wherein interesting statues were placed and the park was illuminated properly.

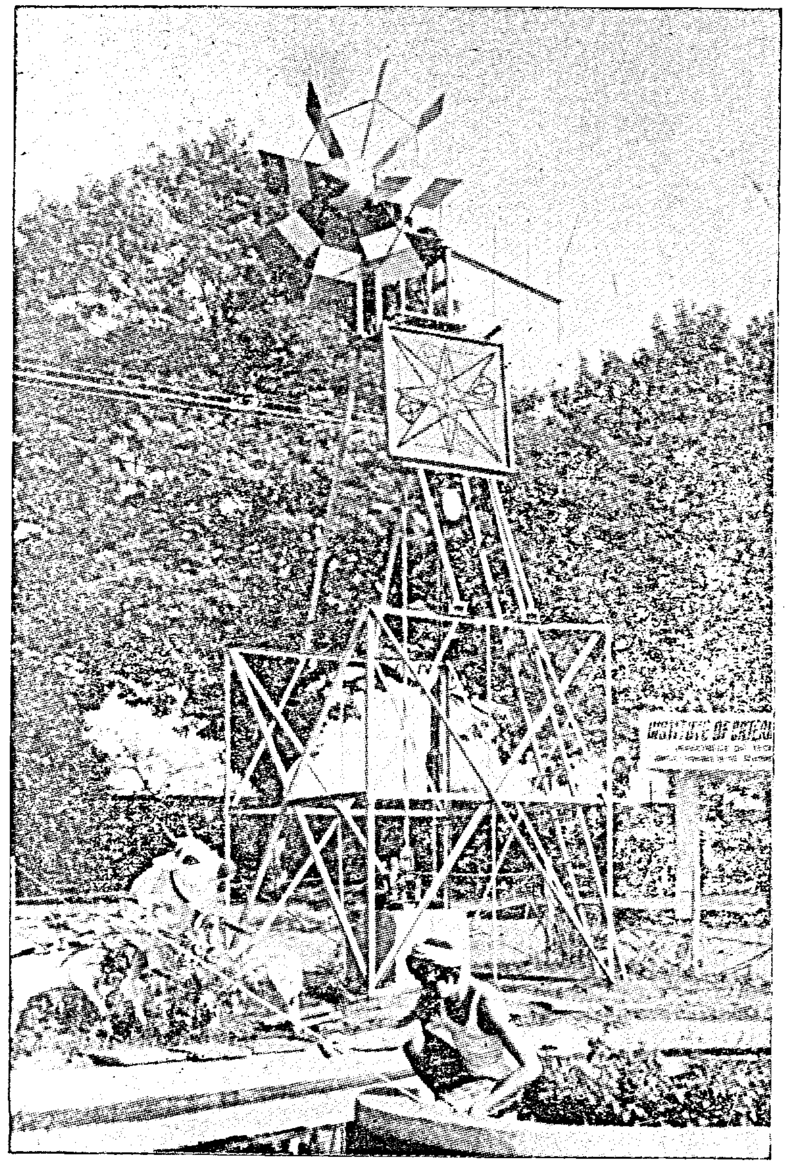
Gopi Krishna dancing model by the Institute of Hydraulics and Hydrology was installed inside the Park. The dancing models were beautifully decorated with serial lights and coloured roofing.

The P.W.D. Pavilion was visited by almost all the visitors to the exhibition. The pavilion received appreciation from visitors from all walks of life.

4. *Award.*—The P.W.D. Pavilion was adjudged as the SECOND BEST among the State Government pavilions, and a prize was awarded.



Building Model of New Secretariat (Madras) Exhibited at ALL INDIA TOURIST TRADE FAIR—1977



Model of a Wind Mill Exhibited at
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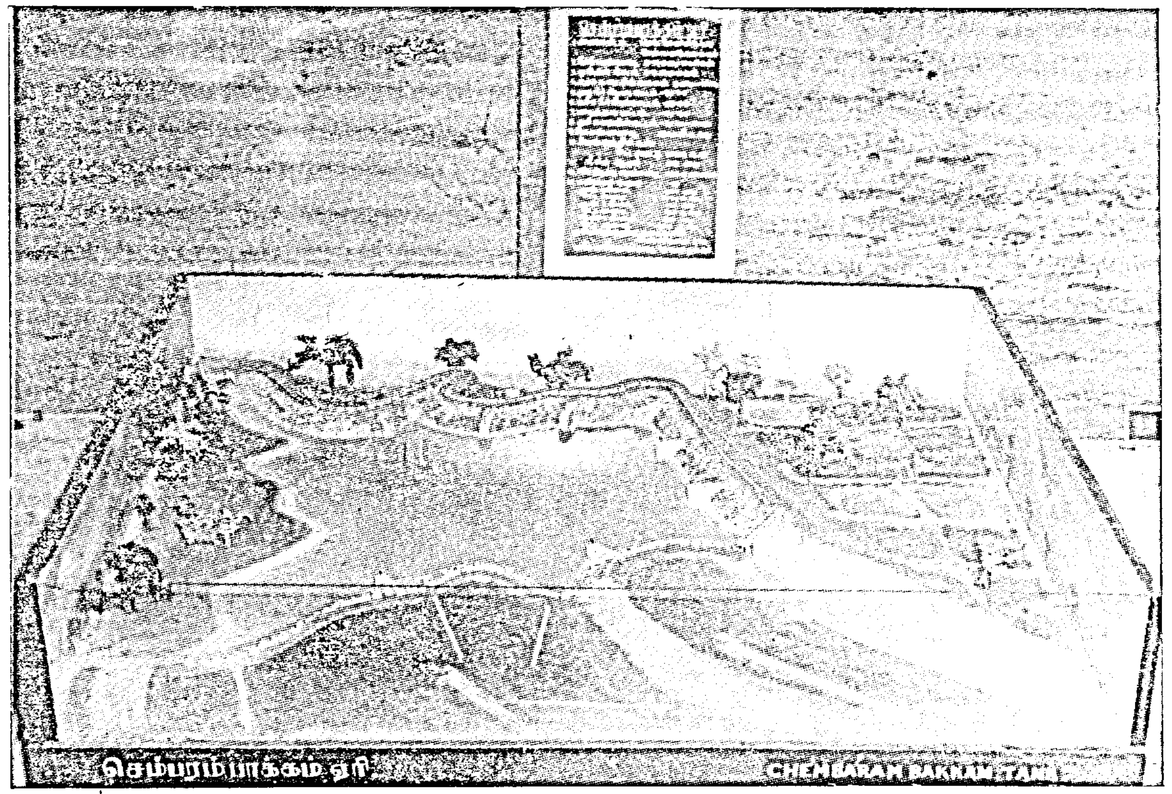

Irrigation Model of Chembarambakkam Tank Exhibited at
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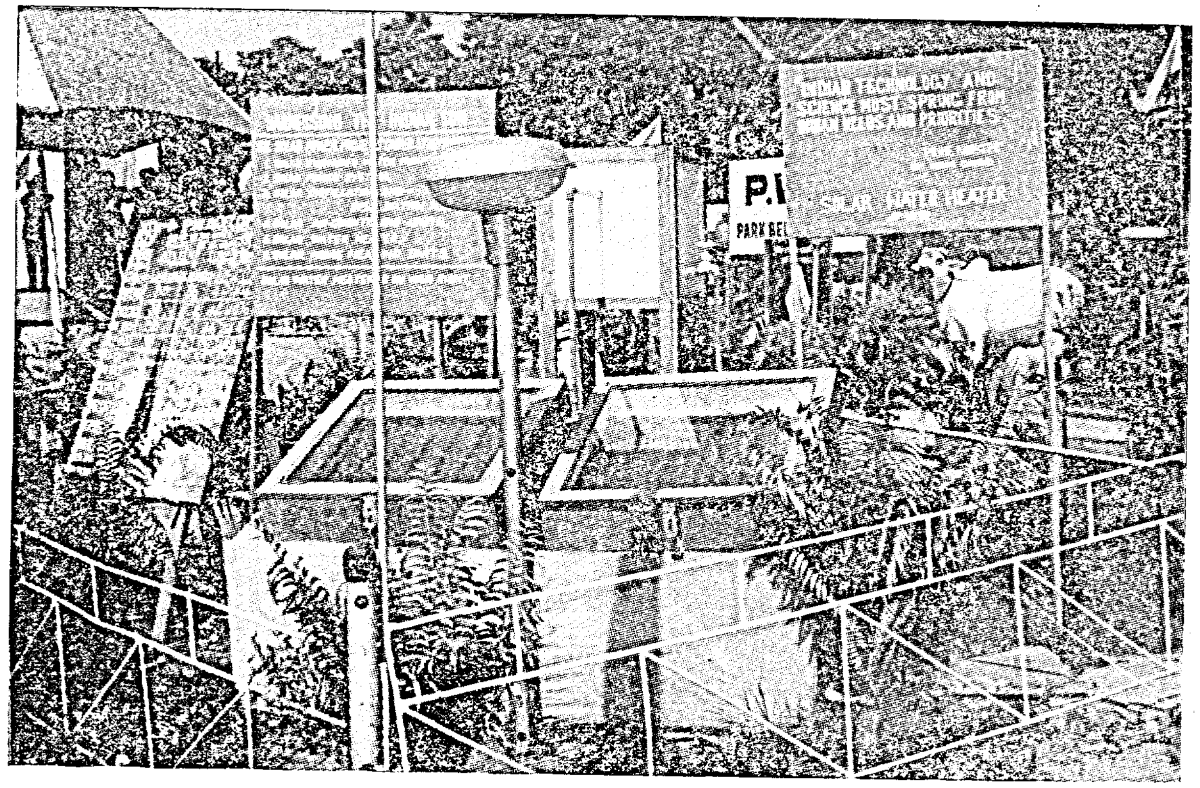

Solar Water Heater Model Exhibited at
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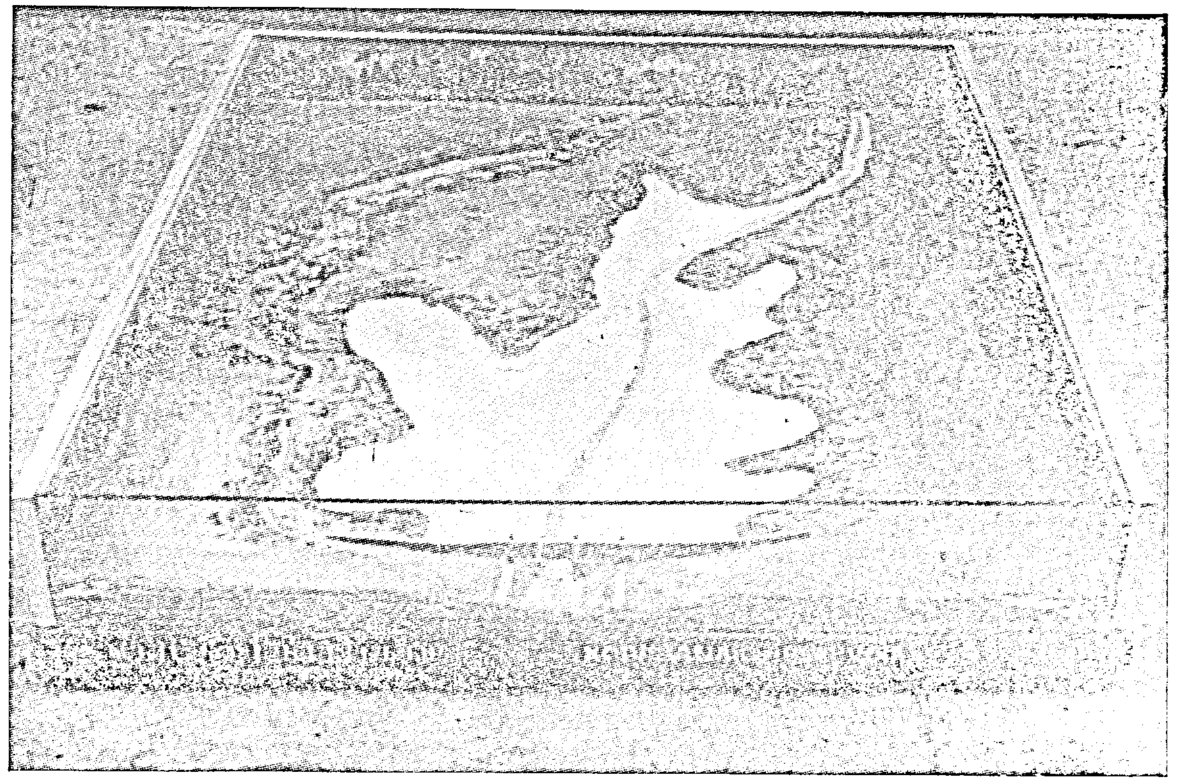

Irrigation Model of Kodaganar Regulator Exhibited at
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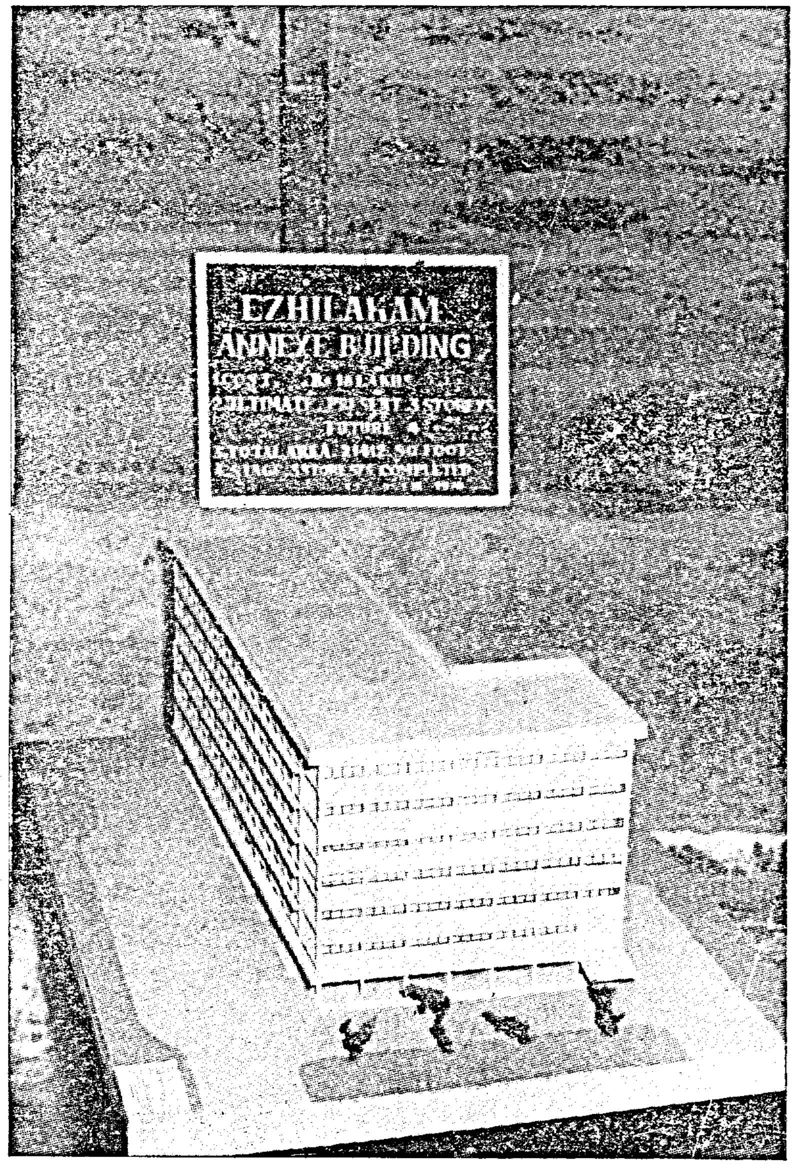
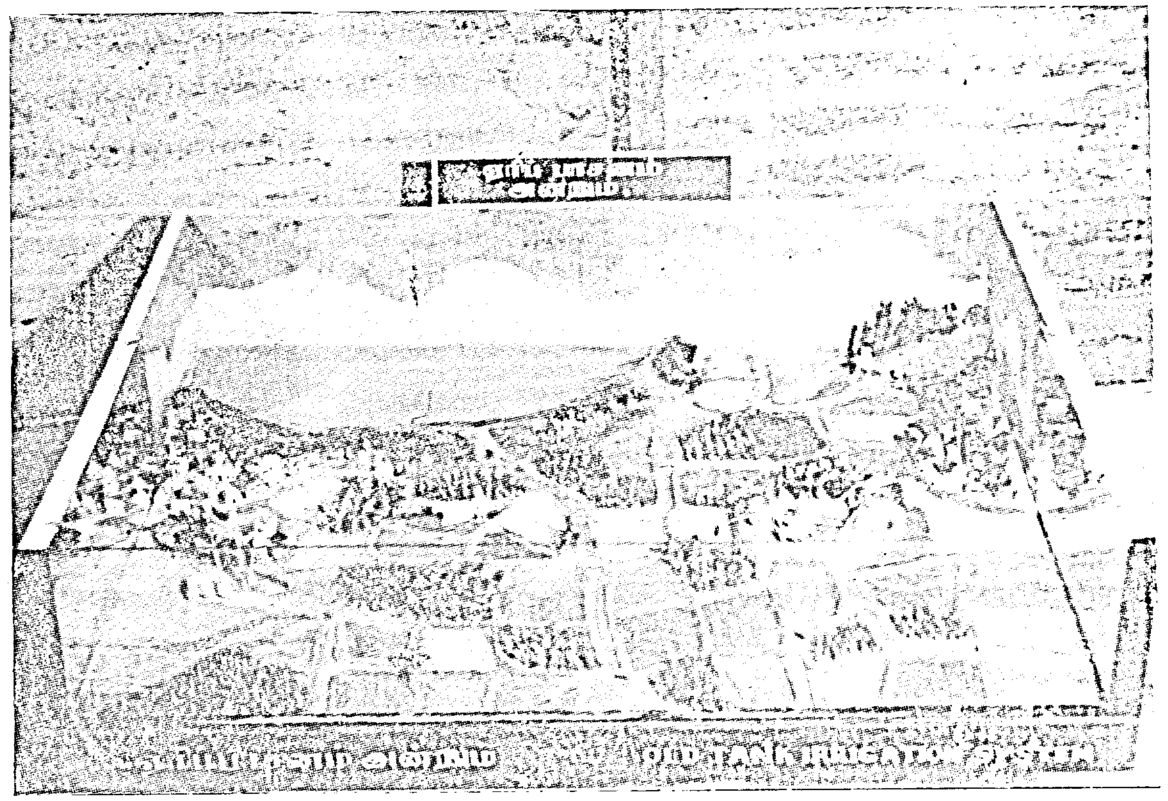


Building Model of EZHILAGAM ANNEXE BUILDING Exhibited at
ALL INDIA TOURIST TRADE FAIR—1977



Irrigation Model Exhibited at
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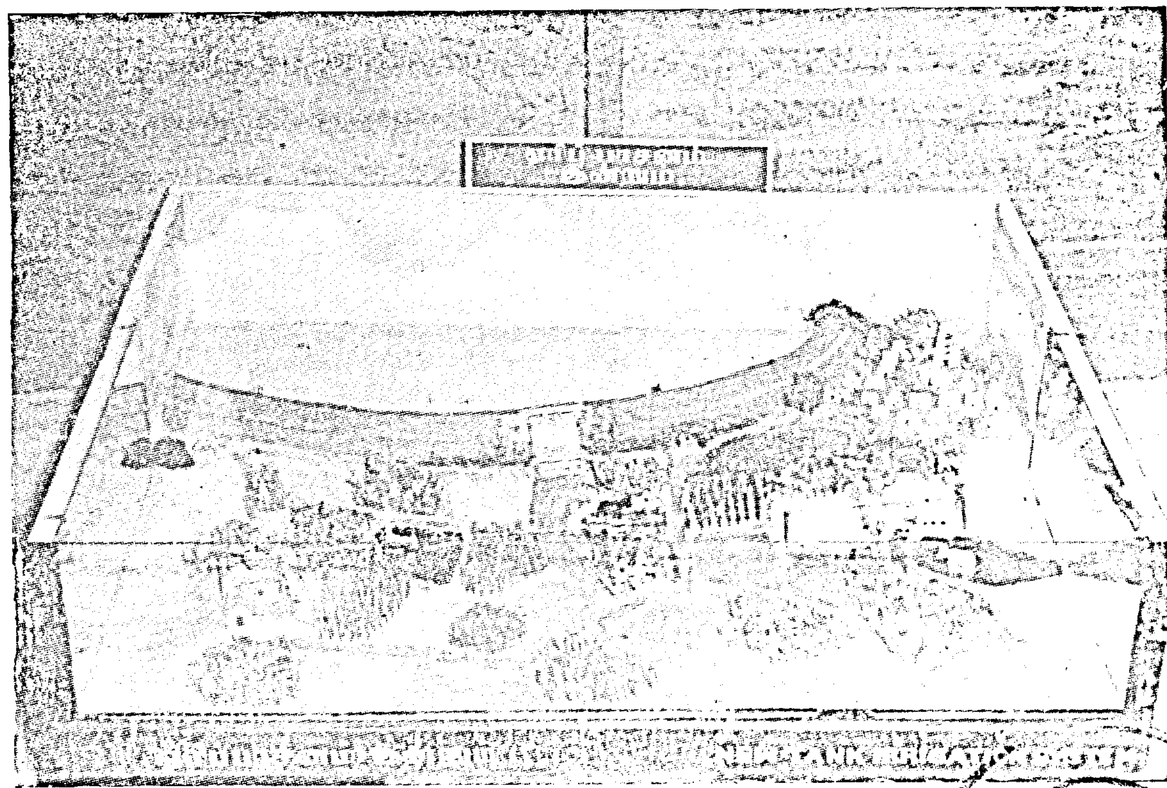

Irrigation Model Exhibited at
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